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THE NORTHERN DISPENSARY;

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1852.

WILSON AND OGILVY, 57, SKINNER STREET, SNOWHILL, LONDON.

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INTO THE

PATHOLOGY AND TREATMENT

OF

DEFORMITIES

IN

THE HUMAN BODY.

BY

JOHN BISHOP, F.R.S. 1797-1873.

MEMBER OF THE COUNCIL OF THE ROYAL COLLEGE OF SURGEONS OF ENGLAND;
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PREFACE.

ON presenting to the profession, as a separate treatise, the author's Investigations into the Deformities of the Human Body, which have already appeared in the pages of the LANCET, he has merely corrected typographical errors, and added a few details suggested by further experience, whilst the fundamental principles of the work remain unaltered.

A new publication furnished the opportunity of proposing the subject in a more popular form, illustrated by numerous and successful cases, and by showy and attractive plates; but the specimens of this kind which have occasionally been given to the public appeared to the author little deserving of imitation, and sometimes even chargeable with delu-

sion; as, for example, when recoveries are announced from organic disease of the vertebræ, implying a restoration of lost osseous matter which experience proves never to occur.

The work is, moreover, exclusively designed for the medical profession, and relates to a subject of great interest and importance, respecting which there is much uncertainty in speculation, and much empiricism in practice. This subject has been too often treated by medical men with neglect, as one of an inferior order, and devolving on the mere mechanician, to whom, in effect, the problem is commonly proposed for solution,—Given a distortion, to discover an instrument that will cure it.—It need not, therefore, excite surprise to find, as will be shown, that means have frequently been employed, even by respectable practitioners, entirely at variance with the intrinsic nature of the case; so that, with the expectation of giving relief, useless torture, or deplorable mutilation, has, in many instances, been inflicted.

The subject of Deformity is here proved, on the contrary, to require the most careful research, and to present a field for the most elaborate mathematical

investigation. The principles of treatment recommended are based on mechanical and dynamical laws, which have received the assent of the most distinguished physical philosophers of the present day. It is, in fact, the wish and aim of the author to induce the members of the profession to advance from the employment in such cases of mere mechanical experiments, to a sound and judicious practice founded on scientific data; and, should any of them doubt, or find it difficult to understand these principles, the author is ready to refer them, for that practical satisfaction which results from high authority, to some of the most eminent surgeons of the metropolis, who have seen and approved the results of their application.

Bernard Street, Russell Square:
Feb. 1852.

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ON

DEFORMITIES IN THE HUMAN BODY.

CHAPTER I.

Preliminary Remarks.—Neglect of the subject of distortions by surgeons of public institutions.—Treatment of cases left to surgical instrument makers.—Mechanical properties of bones, such as hardness, elasticity, rigidity.—Chemical properties.—Effects of chemical changes on the mechanical properties of bones.—Fragility of bones.

THE great number of deformed persons of both sexes who are daily to be seen in every district of the metropolis, must surely tend to impress the public mind with the idea either that distortions are incapable of being cured or prevented, or that the branch of surgery to which they belong is in a very imperfect state. Among the circumstances which have concurred to retard the progress of knowledge in this department of surgery, the following are undoubtedly the principal. It will, I think, be admitted, that the majority of the medical officers of our public institu-

are neglected during that period of the disease when the adoption of methods for relief might have been attended with the most beneficial effects; for the parents, being generally unconscious of the mischief working in the frame of their offspring in the early stages, do not become aware of their melancholy condition until, perhaps, several bones of the spine having been absorbed, anchylosis has taken place, and the distortion consequent upon it is irremediable. Cases of this kind frequently come under the observation of the surgeon.

Among the multitude of persons afflicted with deformities, by far the largest proportion were born with the usual symmetry of figure, and the abnormal condition of the system will generally be found to have commenced in childhood, to have lessened at puberty, and to have terminated at or before the adult state.

It is not intended here to enter into the subject of congenital deformities, or the etiology of any kind of monstrosities, unless they happen to be of that description which renders them susceptible of cure or relief by surgical treatment. In investigating the physiological and pathological conditions which lead to the production of deformities, we must take into consideration the transition from the normal to the abnormal states of many structures; such as those of the bones, the joints, the ligaments, and the muscles, as likewise the constitutional, chemical, and mechanical actions involved in these changes.

Bones.—Many portions of the osseous system are concerned in the production of deformities, more especially those which transmit the weight of the head to the ground. These manifestly include the vertebral column, the pelvis, and the bones of the thighs, legs, and feet.

The circumstances that tend to produce those altered conditions of the bones which lead to deformities, comprise the constitutional derangements of the system which are connected with them, the chemical composition of the bones, and the influence of that composition on their physical constitution. The physical properties of bones, such as density, hardness, elasticity, and tenacity, render them capable, in a greater or less degree, of supporting the various weights to which they are subjected. These mechanical properties vary in degree in different persons, and in the same person at different periods of life, depending on the chemical composition and structure of the bones. In the normal state of bones there is nearly a constant proportion of earthy and animal matter; and whatever state of constitution tends to destroy this proportion, changes, at the same time, the mechanical properties; and hence we arrive at the question—What is the physical state of the system which regulates the proportion of the earthy and animal matter in living bone?

Before attempting any analysis of this subject, it will be desirable to investigate the relation between the chemical and mechanical properties of bone. The vital

force, by means of which all the chemical and mechanical functions are determined, appears to control, in a greater or less degree, the cohesive force of particles in bones of the same composition; but when the energy is the same, the physical properties of specific gravity, hardness, elasticity, &c. will increase as the ratio of earthy to that of animal matter increases, and *vice versâ*. These mechanical properties are essential to the various offices of the osseous system, and many beautiful contrivances are introduced in the structure of bones to adjust them to a specific end, with the least expenditure of material: the flat cylindrical and cuboid forms all exemplify this view of final causes.

In a healthy state of the system the bones are of great strength, and those destined to support the body will bear a weight, gradually applied to them, many hundred times greater than their own. They will bear, without breaking, shocks of great violence, and resist the powerful action of the muscles under all ordinary circumstances. Such are some of the mechanical properties of bones in health; but in disease the case is quite different: all the mechanical properties being more or less impaired under certain chemical changes of the constituent parts of bones. A few examples of the proportions of the earthy and animal matter, obtained in the analysis of healthy and diseased bones, will furnish data from which to deduce consequences of great utility, when applied to the consideration of those constitutional conditions and physical

states of bone which usually terminate in deformities of the skeleton.

Earthy constituents of bone.—The earthy constituents of bone are the phosphate and carbonate of lime, and the phosphate and carbonate of magnesia. According to Berzelius, "the phosphate of lime is to the carbonate of lime as 51·04 to 11·30," so that the quantity of the phosphate of lime is nearly five times greater than that of the carbonate. In children, the proportion of the earthy to the animal matter is less than in adults. In the former, Schreger found that in 98·68 parts the earthy is to the animal as 48·48 to 47·20, or as 1·0271 to 1, the quantities of earthy and of animal substances being nearly equal. In the latter, the earthy is to the animal material as 74 to 20·18, or as 3·66 to 1; which shows that the adult has more than three times as much earthy matter in his bones as the child. In passing from the adult state to old age, a further preponderance of earthy matter in the constituents takes place; for, according to the authority just quoted, the earthy is to the animal part as 84·1 to 12·2, or as 6·89 to 1.

The quantity of earthy matter in the same volume of bone in different parts of the skeleton of the same person is not constant. According to the analysis of Dr. G. O. Rees, the proportions in different bones are as follow:—

	Earthy Matter.	Cartilage.
Femur	62·49	37·51
Tibia	61·01	39·99
Fibula	60·02	39·98

	Earthy Matter.	Cartilage.
Humerus . . .	63·02 . . .	36·98
Ulna	60·50 . . .	39·50
Radius	60·51 . . .	39·49
Squamous portion of temporal bone .	63·50 . . .	36·50
Dorsal vertebræ (arch) .	57·42 . . .	42·58
Head of Femur . .	60·81 . . .	39·19

Hence we perceive that although the quantities of the earthy constituents in the several bones are not constant, yet they do not vary very considerably, and that in the series here selected, the dorsal vertebræ have the smallest quantity. In a fœtus, Dr. Rees found the proportion of earthy matter less than in the preceding table. The analysis already given belongs to healthy structures; but in the abnormal states of the osseous system, as in rickets, the quantity of animal matter predominates over that of the earthy, a condition which, apparently, is never consistent with a healthy state of the system. In a rickety child Dr. Bostock found

The animal matter, 79·75,
The earthy matter, 20·25,

being as 0·253 to 1, or about four times less than the proportion of earthy matter found in the bones of healthy children.

In another rickety child, Dr. Rees found that the earthy was to the animal part as 26 to 74, or as 0·351 to 1. Here the proportion of the earthy matter is greater than in Dr. Bostock's case, but it is three times less than in a healthy child.

Mollities ossium.—In three cases Dr. Rees selected for examination parts of the fibula, ribs, and vertebræ, and found that the mean proportion of the earthy part to the animal was as 29·815 to 70·68.

Each bone having been examined separately, he found as follows :—

	Earthy.	Animal.
Fibula	32·50	67·50
Ribs	30·00	70·00
Vertebræ	26·13	73·87

In healthy persons these same bones contain—

Fibula	60·02	39·98
Ribs	57·49	42·51
Vertebræ	57·42	42·58

From these analyses it appears that the fibula suffers the least loss of earthy matter by absorption, and the vertebræ the most; and, consequently, that the absorption in mollities does not go on equally in different bones. There is, however, a near approach to equality of action, and the same order is maintained in the preponderance of the earthy matter in the different bones examined. On mixing the earthy matter obtained from the above-mentioned bones, they were found to contain 78 per cent. of phosphate of lime, instead of from 81 to 86 per cent., as in health. Hence Dr. Rees concludes that in mollities the decrease of the phosphate of lime is much greater than that of the carbonate. It will be observed that the proportion of earthy matter in rickets is less than in mollities. These are the principal facts at present known

concerning the chemical relations of the earthy and animal matter which enter into the composition of bones in health and disease, and they furnish important data for pursuing the inquiry into the effects of the various states of bone with reference to their functions when considered mechanically. It has been seen that in healthy children the quantity of earthy matter is less in proportion to that of animal matter than at any subsequent period of life. It would therefore appear that the assimilation of the animal matter is effected more rapidly than that of the earthy.

The elasticity of bones varies with their chemical composition, and, within certain limits, depends on the quantity of earthy matter which they contain. When the earthy, compared with the animal matter, diminishes, the bones begin to lose more or less of their elasticity: they become more compressible, and if driven out of their normal figure by the weight of the body pressing on them, do not readily return to it; but as long as a sufficient portion of their elasticity remains, no deformity of the bones can take place. The elasticity requisite to preserve their figure remains constant as long as the quantity of the earthy matter is not less than that of the animal constituents of the bone. In rickets and mollities, where the proportion of earthy matter is very small, the bones become almost perfectly inelastic: they will bend in any direction by the application of force, and they will not, under ordinary circumstances, return to their primitive figure. In this manner the deformity, once produced, continues (even after the bone becomes sound), unless mechanical

assistance be interposed. Many, nay most, of our best surgeons believe and maintain that what is vaguely understood to be the *vis medicatrix Naturæ* is quite sufficient to restore a distorted limb, provided time be allowed to enable the bone to acquire the hardness and strength necessary to support the superincumbent weight. This, however, is a most deplorable error; no time, no natural play of the vital powers of the system, is sufficient to restore a distorted bone to its normal figure, after it has lost its elasticity in consequence of a deficiency in its due proportion of earthy matter. At any subsequent period, when the bones acquire the proportions of constituents necessary to a healthy state, the deformed condition will be found to have remained stationary during the increase of their density and elasticity. To make this more clear, let us suppose any bone, such as the tibia of a child, so pliable as to be incapable of bearing the weight of the body, and that it becomes in consequence curved in one or more planes. If this bone were elastic, it would return to its primitive state as soon as the pressure was removed; but being inelastic, it retains the figure which the force has caused it to assume. And, as the bone is, in the first instance, at a minimum of density, and gradually acquires a greater amount of earthy matter, and, consequently, of elasticity, this very elasticity, which would originally have kept it straight, actually retains it in the curved form which the external force had caused it to assume. But this is not a property peculiar to bone, for it is common to all elastic bodies. By elasticity, we mean that tendency which a great

number of bodies possess to recover their pristine figure, after having been bent, twisted, extended, or compressed; and that body is said to be the most elastic which recovers its figure with the greatest energy, supposing the compressing force to have been the same. A perfectly elastic body would recover its figure with a force equal to that which has been employed in distorting it. The preceding definitions appeared to be necessary, for there exist in the minds of many persons very different ideas of the nature of elastic bodies.

The difference in the degrees of elasticity of different bones due to different states of chemical combination, may be discovered by means of the sounds which they yield, when properly excited into a state of vibration. For instance, let us suppose the figure of any two bones to be the same; that they are of similar length, breadth, and thickness; that they are made to vibrate in a similar manner; and that they differ with respect to the proportion of the earthy, compared with that of the animal matter, and also in their specific gravity: now the number of vibrations which they yield will be directly as the square roots of their elasticities, and inversely as the square roots of their specific gravities,* and it will be found that any in-

* According to Giordano Riccati, if n be the number of vibrations of any elastic body, g its specific gravity, r its rigidity, and e its elasticity, then, for bodies of the same dimensions, n varies as $\sqrt{\frac{r}{g}}$; but in bodies of the same dimensions, e varies as r; therefore, also, n varies as $\sqrt{\frac{e}{g}}$. — *Mem. de la Soc. Italiana*, tom. i. p. 490.

crease of earthy matter will cause the elasticity to increase faster than the specific gravity; and therefore, the bones which have the greatest proportion of earthy matter will produce the most acute sounds; and if we take perfect segments of the bones of old persons and of children, we shall find that the bones of the former will produce the more acute sounds of the two, in consequence of their greater elasticity. In this way the comparative elasticity of most bodies may be found, and it is an experiment that might be easily made. But, although the elasticity of bone is of great importance, in relation to its strength and its power to perform its functions in the human body, the further investigation of the subject would lead to a more profound analysis than is contemplated in this treatise.

In a healthy young man, the proportions of earthy and animal matter in the bones are adjusted to bear the greatest weight, to sustain the most vigorous play of the muscles, and to resist the greatest amount of violence with the least danger of being fractured; but in old age, although the bones are then most elastic, they become more brittle, and are, consequently, more liable to be fractured. In childhood, on the contrary, the bones, in consequence of their containing the greatest proportion of animal matter, are more susceptible of bending: they are more compressible, but less fragile on receiving a shock.

It appears from the experiments of Professor Robison, that the strength of bone is greater than that of free-stone, lead, box, yew, oak, elm, or ash, and

that they stand in the following comparative relation :—

Fine freestone	1·0
Lead	6·5
Elm and ash	8·5
Box, yew, oak	11·0
Bone	22·0

Hence we see that bone is twice as strong as oak. Professor Robison also found that a piece of bone an inch square will bear 5000 pounds weight; but we are not informed from what portion of the skeleton the bone was selected, or whether it was from a young or an old person, &c.*

In the distribution of osseous matter, utility and economy of substance are perceptible in every part of the body. Wherever strength is most required, bone is made of such a figure as will give the greatest strength with the least expenditure of materials; and in those parts where a large surface is required, the figure is made to correspond: thus, the cylindrical, the cuboid, the prismatic, and the flat, are some of the figures introduced in the skeleton. The weights which cylindrical or prismatic flexible columns will bear perpendicularly, when their bases and compositions are equal, is in the inverse ratio of the squares of their length; therefore, if we take any bones, of similar materials and thickness, but of which the lengths are respectively as 1, 2, 3, 4, 5, they will support weights

* See Gregory's Mechanics, vol. i. c. 5.

without flexion in the proportions, 1, $\frac{1}{4}$, $\frac{1}{9}$, $\frac{1}{16}$, $\frac{1}{25}$; the necessity, therefore, for dividing the columns which sustain the trunk by means of the joints, independently of the use of the latter for locomotion, is obvious. The lateral strengths of two cylindrical bones of equal weight and length, of which one is hollow, and the other solid, are respectively as the diameters of their transverse sections. Thus, let *a b*, *d c* (figs. 1 and 2) represent the sections of the two bones; then the strength of the tube *d c* is to that of the solid *a b*, as the line *d c* is to *a b*.

Fig. 1.

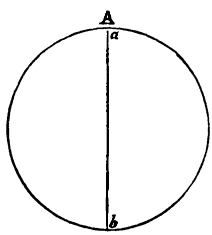
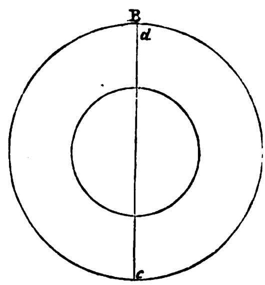


Fig. 2.



From this proposition it was long since observed by Galileo, that nature greatly augments, in a thousand ways, the strength of bodies without increasing their weight; and that if a wheat-straw which supports the ear, that is heavier than the whole stalk, were made of the same quantity of matter, but solid, it would bend or break with far greater ease than it now does. The feathers of birds, as well as the bones of animals, present similar provisions for the combination of strength, lightness, and economy of material. The strength of

bones cannot, however, as might possibly be inferred from the preceding proposition, be increased with the same quantities of matter indefinitely, because, when the diameter of the tube exceeds certain dimensions, it will become so thin and fragile as to break almost without offering any resistance. The lateral strengths of tubes and solid cylinders of the same material and of equal lengths, are as the areas of their sections and their diameters conjointly.

From the deductions which may be drawn from the preceding proposition, Galileo very justly concludes that "there are limits set to the magnitudes of the works of nature and art, and that the size of ships, palaces, and temples, trees, and animals, cannot surpass certain dimensions; and he observes, that large animals have neither strength nor speed proportionate to their bulk, and that if there were any terrestrial animals much larger than those we know, they could hardly move, and would be much more subject to the most serious accidents; and also, that it would be impossible for nature to give bones to men, horses, or other animals, if they were enlarged to immense heights, so as to perform their offices proportionally, unless these bones were composed of materials much more firm and resisting, or they were made of a thickness out of all proportion, rendering the figure and appearance of animals monstrous." Mr. Banks has found that an oak-rod one inch thick, supported at each end, will break by its own weight at the length of 57·45 feet, and a similar one of iron at 38·223 feet. Emerson

also found that the cohesive strength of bone is double that of oak, whilst its specific gravity is to that of the latter only as 1656 to 1170, or as 92 to 65. In the megatherium and elephant, the length of the bones of the legs is small, compared with their diameters, and, consequently, they possess greater comparative strength as columns for supporting their ponderous superstructures.

In the thigh-bones of most animals, an angle is formed by the head and neck of the bone with the axis of its body,—a form which prevents the weight of the superstructure coming vertically upon the shaft, converts the bone into an elastic arch, and renders it capable of supporting the weight of the body in standing, in leaping, and in falling from considerable altitudes.

There is a rule very convenient to be observed in all cases where a comparison is to be made of the strength of bones, or of any other bodies composed of similar materials—namely, the breadth, multiplied into the square of the depth, and divided by the product of the length and weight, must be a constant quantity: that is, for example, if we take b, d, l, and w, for the breadth, depth, length, and weight, employed in an experiment, and B, D, L, W, those proposed to be compared, then, to produce a like effect, we must have—

$$\frac{b\,d^2}{l\,w} = \frac{B\,D^2}{L\,W}.$$

Mr. Porter * instituted a series of experiments in

* See Cyclopædia of Anatomy and Physiology, vol. i. p. 441.

order to ascertain the comparative fragility of bones; but the attempt was unsuccessful; and he candidly owns that he was obliged to leave the subject as it stood before, without even attempting a solution of the difficulty. He further says: "We compared the respective thicknesses of the thigh-bone in the adult and in the aged, the section being made exactly in the middle: we weighed equal lengths of similar bones; we softened equal lengths and equal weights by means of dilute muriatic acid, and we burned equal portions and weights also, with a view of comparing them under different circumstances, but could never arrive at any fixed or certain conclusions." It is to be regretted that no mention is made of what was done with the bones after they had been treated in the manner above described, or of any attempt made to ascertain whether the fragility, strength, and elasticity, increased or diminished with the altered proportions of earthy and animal matter; and though the experiments made were unsatisfactory, still they might, if detailed, have saved future investigators the labour of repeating this kind of experiments in a similar way. There can be no doubt that there is sometimes a difference in the structure of bones, and in the cohesive force exerted between their particles, when the chemical composition is the same; but this is not sufficient to account for a rickety state of the skeleton; and, although the quantity of the earthy, compared with that of the animal matter, might be found the same in a rickety as in a healthy person, it must be remembered that the

examination of the bones is usually made, not at the moment of their state of least elasticity, but when the bones have acquired their proper density by the acquisition of the earthy phosphate, the deformity being the result of a previous state of morbid action.

Mr. Porter remarks that a deficiency of earthy matter is not one of the essential causes of a rickety state of the skeleton; and M. Ribes observes that the fragility of bones depends merely on *a change of action:* but this vague term comprehends any kind of change that may take place in the constitution of bone.

Independently of that fragility which is common to the bones of aged persons, they are occasionally observed to become exceedingly fragile under certain morbid conditions of the system. A case of this kind is detailed in Gooch's chirurgical works. A woman broke her leg, without the slightest violence, whilst in the act of walking from her bed to her chair. Shortly after the accident she suffered from scurvy, and bled much at the gums. The legs and thighs, which were œdematous, became excoriated, and discharged a yellow ichor. From the commencement of the attack until her death, the bones continued to become softer. The spine was greatly distorted, so that her height, which had been five feet five, was diminished to four feet. All the bones, except the teeth, were more or less affected, and capable of being cut with a knife without difficulty. The bones of the head, thorax, spine, and pelvis, were nearly of the same degree of softness; but those of the lower were much more affected than those

of the upper extremities, the former being found to have changed into a kind of parenchymatous substance, like dark-coloured liver. The thumbs became broad, and the phalanges of the fingers curved, by her efforts to raise herself in bed, to which she was confined in a sitting posture. It was remarked that the bones which in a healthy state are most hard, and contain the greatest quantity of marrow, were most affected; and it was inferred that as the only patches of osseous laminæ left were on the external surface of the bones, the disease must have begun internally, and Mr. Gooch thinks that the marrow in its changed condition had acquired a dissolving quality.

Two cases of extreme fragility of the bones occurred amongst my patients: one of these, a middle-aged woman, suffered from a malignant tumour in the thigh, and the bone broke while she was in the act of lifting the leg out of bed. In the other case, a man, about forty-five years of age, whose general health was greatly impaired, became much emaciated. The lower extremities were subject to hæmorrhagic ulcers. He fractured the os humeri on the right side, in the act of merely raising himself in his bed.

CHAPTER II.

Sketch of the vertebral column.—The vertebræ levers of the first order; the whole column a lever of the third order.—Normal figure of the vertebral column, how ascertained.—Strength due to figure estimated.—Influence of weight acting vertically estimated.—Ordinates and abscissæ of the spinal curves computed.—Figure of the bodies of the vertebræ.—Articulations and motions of the vertebræ.—Intervertebral cartilages.—Curvature of the spine due to the cartilages principally.—Tables of vertebræ and cartilages.—Flexibility of the spine due to the elasticity of the intervertebral cartilages.—Flexibility of the three regions of the spine compared and estimated; mistaken views of authors on this subject.—Ligaments of the spine.—Effects of equal and unequal pressure on the intervertebral cartilages; loss of height during their compression estimated.—Elasticity of intervertebral cartilages different from that of inorganic matter.—Effects of equal and unequal pressure on the vertebræ.—Injurious effects of neglecting unequal pressure illustrated.

THE VERTEBRAL COLUMN.

It is quite unnecessary to encumber these pages with such details of the vertebral column as may be found in any elementary anatomical work. Such erroneous statements respecting distortions of the spine have, however, been made, and so many extraordinary and empirical methods have been employed for relieving the various abnormal states of this organ, that a closer

examination into its physical constitution will here be instituted, in order to establish the principles on which its diseases and distortions should be treated.

The human spine, whether considered anatomically or mechanically, is an organ of wonderful construction. Its figure is pyramidal, and with reference to the mesial plane of the body it is curved in opposite directions. It consists of twenty-four bones, and twenty-three intervertebral cartilages Each bone is a lever of the first order, the power being the force of the muscles acting forwards and backwards, and the fulcrum a variable line in the subjacent intervertebral cartilage. The whole spine, when considered as a rigid body, is a lever of the third order, its axis of rotation being in the sacro-lumbar articulation, the power being the force of the muscles that draw the trunk backwards and forwards, and the weight being the head and upper extremities, which are more distant from the fulcrum than the power.

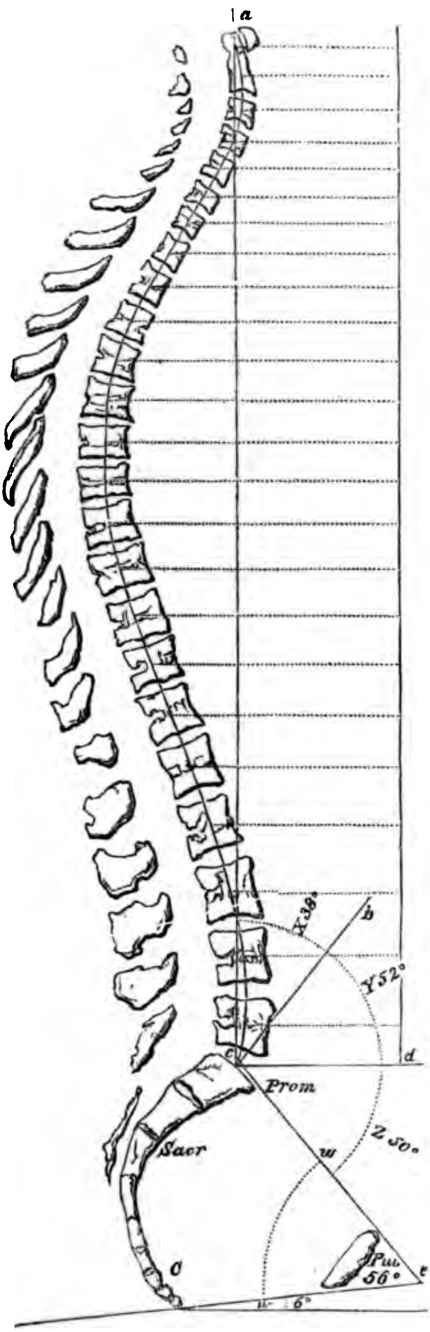
The vertebral column is thus capable of acting either as one, or as many levers, for moving and supporting the numerous organs with which it is connected. The bones confer on it strength and rigidity, whilst the intervertebral substance gives it pliability and elasticity. The manner in which the vertebræ are connected together by osseous and ligamentary matter, restricts within definite limits their movements upon each other, so that the integrity and security of the spinal cord are preserved; and although each joint admits of only a limited range of motion, yet, as the number of these

joints is considerable, a great degree of mobility is conferred on the entire column.

When a mesial section of the body is made, without any plan being adopted to restrict the movements of the spine, the elasticity of the intervertebral cartilages and ligaments will cause the several parts to be distorted from their normal position, and the whole figure of the spine will, in consequence, be deranged. In order to avoid this, MM. Weber * removed from the trunk of a dead body the intestines, and such of the muscles only as they found necessary, without disturbing the ligaments of the spine and thorax. They then poured into the cavities of the abdomen and chest a sufficient quantity of liquid plaster of Paris, by which means they obtained a perfect cast of the vertebral column, with all its inflexions. The parts having been thus fixed in their normal positions, the whole was bisected in the mesial plane, and a drawing of this section of the spinal column was taken. This drawing has been reduced, and adapted to our present purpose. MM. Weber have thus furnished us with the only true outline of the figure of the spine, including the relative positions and proportions of its several bones and cartilages, which has hitherto been obtained. The figure of the spine is an irregular curve, the superior and inferior portions of which, viewed in front, are convex, and the central portion is concave. By this triple curvature, the spine is said, by Rollin and Majendie, to

* Mechanik der Menschlichen Gehwerkzeuge. Göttingen. 1836.

Fig. 3.



Ordinates.		Abscissæ.	
—·000	......	000	CERVICAL.
—·125	......	·575	
—·125	......	1·200	
·065	......	1·825	
·350	......	2·400	
·650	......	2·945	
1·000	......	3·500	
1·400	......	4·100	DORSAL.
1·750	......	4·850	
2·200	......	5·600	
2·480	......	6·600	
2·650	......	7·150	
2·750	......	7·500	
2·750	......	8·290	
2·620	......	9·750	
2·450	......	10·725	
2·140	......	11·700	
1·850	......	12·625	
1·400	......	13·675	
1·000	......	14·850	LUMBAR.
·560	......	16·050	
·200	......	17·400	
—·040	......	18·700	
—·030	......	20·150	
—·000	......	21·100	

Scale.—One quarter of the size of the adult male.

be sixteen times stronger than if it were straight.* It will be observed, that the vertical line *a c* passes nearly through the axes of the occipito-atlantic and sacro-lumbar joints, and that the three lower cervical vertebræ, the whole of the dorsal, and the first, and nearly

* This must surely be altogether a mistake. It is true, that if a force acting vertically on the upper edge of a straight, thin, elastic lamina, placed upright on the ground, produce (n) curvatures in it, the resistance of the lamina, when in a state of equilibrium, is rather more than $(n + 1)^2$ times the weight which it would bear in its vertical position without bending (see *Penny Cycl.*, Art. "Spring"). But this case is very different from that of the spine, which is not only *not* a thin lamina greatly elastic throughout, but its curvatures are its natural and proper figure, and, therefore, there can be no tendency in the spine, when pressed upon by a vertical force, to restore itself to a state of straightness, whereas the great resistance which the lamina opposes to the force of pressure is entirely owing to this tendency. So far, then, from being stronger in consequence of being originally bent into several curves, the spine is, in fact, much weaker, and the greater the radius of curvature at any point of the axis, the less will be the strength. In confirmation of this statement, Dr. Young says—"The curvature of the axis from any point will always be proportional to its distance from the line of direction of the force, not only while the column remains nearly straight, but also when it is bent in any degree that the nature of the substance will allow; if the column was originally bent, any force, however small, applied to the extremities of the axis, will increase the curvature according to the same law"—(Nat. Phil., vol. i. pp. 138, 139. The advantage of the curved form is, that the shocks and jars applied at either end of the spine tend to bend the axis, which would, if straight, crush some of the vertebræ, in consequence of the force acting on them in a perpendicular direction.

the whole of the second lumbar, lie out of this line. The line drawn through the centre of the bodies of the vertebræ gives the figure of their curvature; the horizontal lines drawn from the line *a c* to the curved line, show the distance of this line from the centre of each vertebra. When the body is in the erect posture, the line *a c* marks the direction of the force arising from the weight of the head, and, consequently, of any heavy body placed upon it, and the horizontal lines show the distances at which the force acts on each vertebra. The same weight also acts upon any vertebra in curving the spine with a force proportional to the length of the horizontal line at that vertebra. Those vertebræ which lie anteriorly to the line *a c*, are thus acted on in an opposite direction to those which lie posteriorly to it.

From what has just been stated, it appears that in the erect posture of the spinal column, the vertebræ traversed by the line *a c* must resist a weight placed on the head with the greatest mechanical advantage; and that the sixth and seventh dorsal vertebræ, which are the most remote from the line *a c*, must resist it with the least. Hence we may readily understand why it is that when the spine is mechanically incurvated in the mesial plane, it is so most commonly at this part. The line *b c*, perpendicular to the plane of the sacro-lumbar articulation, makes the angle *X* with the vertical equal to 38°; and *Y* with the horizontal equal to 52°; the sacrum with the pelvis, 56°; the lower margin of the pelvis with the horizon, 6°; and the promontory *d c e* with the pubis *Z*, equal to 50°; and

with these data the angle which the pelvis makes with the spine is found. The numbers in the column of ordinates represent the distances, measured in inches, of the centre of each vertebra in the adult man from the line *a c*, of which those lying in front of the line are marked with the negative sign. The numbers in the column of abscissæ denote the distances of each ordinate from the point *a*, the origin of the curve. By the help of these two columns, it will be easy to describe with accuracy the figure of the spine in its normal state, and in an adult person.

The transverse section of the bodies of the vertebræ is an oval, of which the length is to the breadth, in some of them, nearly as 1·4 to 1. The greater axis is directed transversely, or perpendicularly to the mesial plane of the body in which the minor axis lies. The advantage of this figure over a circular body of equal area is, that it projects less into the cavities of the thorax and abdomen, and affords more space for the passage of the spinal cord. The spongy structure of the body diminishes its specific weight; and though less strong than solid bone, it is less susceptible of fracture. The areas of the articulating surfaces of the bodies increase from the second cervical to the last lumbar vertebra, so that the surfaces of the bones increase as the weight they have to sustain augments —an arrangement by which the stability of the vertebral column is secured. In order to give the spongy parts of the bodies of the vertebræ greater power to resist the action of the spinous and transverse processes,

they are furnished with a band of hard, elastic, lamellated structure: the same kind of material also enters into the composition of the processes. In consequence of the curved figure of the spine, the articulating surfaces of the bodies of the vertebræ are nearly all oblique to the horizon; some are directed downwards, such as the last lumbar and lower cervical; others, as the lower dorsal, are directed upwards. In some, the posterior portion of the body is thicker than the anterior, as in the middle dorsal vertebræ. All these variations are necessary to the formation of the proper curve, as will be readily seen by inspecting the preceding figure.

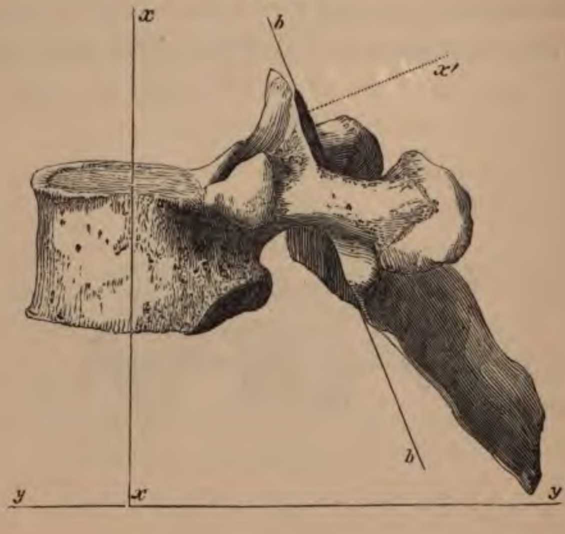
The atlas is destitute of a body and intervertebral cartilage, and is composed of laminated structure. It is articulated to the condyles of the occiput by a ball-and-socket joint, in such a manner that the head cannot turn laterally without the atlas, nor the atlas without the head. The atlas, however, is articulated to the dentata in such a manner that it can rotate freely upon it through a large arc of a circle. This arises from

Fig. 4.

the articulating surfaces of the latter being portions of a conical surface (*b b*, fig. 4), whose axis, *x x*, passing through the odontoid process *a*, coincides with the axis of motion of the corresponding oblique surfaces of the atlas—an arrangement which is dissimilar to that of any succeeding vertebra. By means of the articulations of the atlas with the occiput and dentata, the head can move backwards and forwards in vertical planes through a large horizontal range. The dentata cannot revolve on the succeeding vertebra (fig. 5), in consequence of

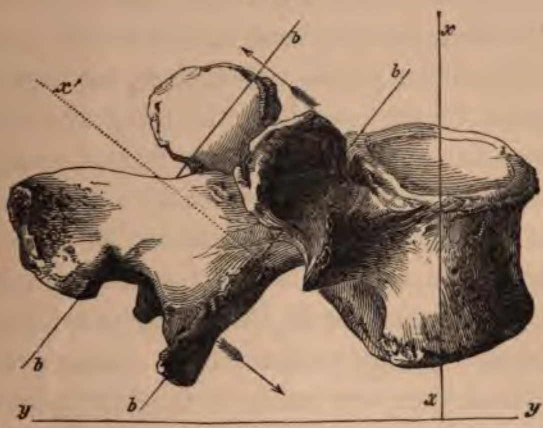
Fig. 5.

Fig. 6.



the oblique articulating surface, *b b*, of the latter lying in one and the same plane, to which *x'* is perpendicular, which line is inclined to the axis of revolution, *x x*. In the dorsal vertebræ, the oblique surfaces (fig. 6), *b b*, do not lie in the same plane, but are

Fig. 7.



directed so as to form portions of a conical surface about the axis of the body, *x x*, whereby they are allowed a certain amount of twisting action. In the lumbar vertebræ (fig. 7), the oblique processes, *b b*, are large, and their surfaces are excavated, and almost perpendicular to the upper surface of the body, so as to prevent any twisting or spiral motion whatever of the trunk about the axis, *x x*.

We have seen why the vertebræ cannot revolve about the axis of their bodies except in a limited degree, and we have now to consider whether they have any sliding

motion, and also what takes place in bending the body either backwards, forwards, or laterally. The vertebræ cannot slide forwards, on account of the oblique process of the next lower vertebra, nor backwards, owing to the inferior oblique process of the next superior, unless these processes were to slide off from each other. That this cannot occur in any natural posture of the spine, is evident from the consideration, that if such an extent of motion in the processes took place, not only would dislocation be the result, but the trunk would have a degree of flexion far greater than that of which it is known to be capable in the healthy subject. With respect to sliding laterally, in the five lower cervical vertebræ there is very little opposition to a lateral sliding at right angles to the mesial plane, from the circumstance that the surfaces of the oblique processes on both sides are very nearly in the same plane, and therefore they are prevented from slipping off each other in that direction chiefly by the several ligaments by which they are bound. In the dorsal, the surfaces of the oblique processes are rather inclined to each other, and therefore offer a greater obstacle to such lateral sliding; whilst in the lumbar, the inclination of these surfaces is so considerable that the vertebræ are firmly locked the one within the other. It will be observed, that the situation of both the superior and inferioroblique processes precludes the possibility of their sliding diagonally. In bending the body either laterally, backwards, or forwards, the figures of the vertebræ present

no impediment to the rotation of the one about the other, the centres of motion being, in the first case, the base of the superior oblique process of the next lower vertebra; in the second, the superior process of the next lower; and, in the third, the compressed anterior portion of the subjacent intervertebral cartilage. These motions, however, are reduced within very narrow limits by means of the ligaments and muscles.

In order to give the spine the requisite flexibility and elasticity, there is interposed between each pair of contiguous vertebræ, except the first and second cervical, a highly elastic fibrous substance—the intervertebral cartilage. The twenty-four vertebræ are consequently furnished with twenty-three cartilages. These yellow fibrous tissues have been minutely examined by E. H. Weber, by whom they have been described and figured in Meckel's Archives for the year 1827. It appears that each cartilage is composed of a bundle of fibres which are parallel to the axes of the bodies of the vertebræ, and bound together by the membrane in which the spine is enclosed. When the body is inclined forwards, these fibres are bent at the anterior, and straightened at the posterior margin of the articulating surfaces of the vertebræ; the reverse takes place on bending the body backwards. With a view to estimate the curvature and flexibility of the spine, the Messrs. Weber have measured the osseous and cartilaginous portions of it. The curved figure of the spine depends principally on the unequal heights of the

anterior and posterior portions of the intervertebral cartilages; and what is due to the bones, and what to the cartilages, is exhibited in the following table, wherein the unit is a millimetre=0·03937 inch. The first column contains the number of each vertebra reckoned from above downwards; the second, the mean altitudes of the bodies of the vertebræ; the third, the mean heights of the intervertebral cartilages; the fourth, the difference between the heights of the anterior and posterior portions of each vertebræ; the fifth, the difference between the heights of the anterior and posterior faces of the intervertebral cartilages; the sixth, the mean diameters of the cartilages. The signs + and − denote the excess or defect of the anterior in relation to the posterior portion.

	1.	2.	3.	4.	5.	6.
CERVICAL.	1	0·00	0·00	0·0	0·0	0·0
	2	31·50		+3·0		14·7
			2·70		+0·6	
	3	13·20		+0·8		14·9
			3·55		+0·1	
	4	13·05		−0·1		14·2
			2·65		+1·3	
	5	13·10				15·1
			3·75	−0·6	+1·5	
	6	12·00				15·9
			4·60	−1·0	+1·2	
	7	13·00				15·2
			3·45	−0·8	+0·1	
		95·85	20·70	+1·3	+7·8	

DORSAL.	1	16·80		−1·0	+0·8	17·0
			3·40			
	2	18·60				19·8
			3·15	−0·2	−1·3	
	3	18·50				21·3
			2·40	−2·0	−1·2	
	4	19·20				21·9
			1·90	−1·9	−1·8	
	5	19·85				26·4
			2·15	−2·0	−0·7	
	6	19·40				27·5
			3·10	−2·4	−1·4	
	7	19·50				28·5
			3·15	−1·5	−1·3	
	8	20·45				27·8
			4·30	+0·3	−1·2	
	9	20·45				28·0
			3·20	−0·6	−1·2	
	10	23·20				28·8
			2·50	−1·4	−0·6	
	11	23·20				
			5·65		+0·7	
	12	23·80		−1·0		
		242·95	34·90	−13·3	−9·2	
LUMBAR.	1	26·60	4·70		+2·0	27·9
				−0·8		
	2	28·15	4·85		+2·1	29·1
				−1·1		
	3	28·15	6·90			29·1
				+0·7	+2·2	
	4	26·75	6·85			29·3
				+1·7	+3·3	
	5	26·30	8·65			29·5
				+6·2	+2·3	
						27·7
			10·90		+9·2	
		135·95	42·85	+6·7	+21·1	

By comparing the several amounts in this table, we see that in columns 4 and 5 the heights of the anterior

and posterior sections of the bones and cartilages in the cervical, dorsal, and lumbar regions are unequal; the aggregate differences being as follow :—

	Heights of Vertebræ.	Heights of Cartilages.	Sum.
Cervical	+ 1·3	+ 7·8	+ 9·1
Dorsal	− 13·3	− 9·2	− 22·5
Lumbar	+ 6·7	+ 21·1	+ 27·8

From this estimate it is quite apparent that the spine can never became a straight column, that the cervical and lumbar curves are occasioned principally by the intervertebral cartilages, and the dorsal curve chiefly by the wedge-like figure of the bodies of the vertebræ; although, as appears from the table, the cartilages, as well as the bones, are thicker at the posterior part in the dorsal region. As the bodies of the vertebræ are inflexible, the flexibility of the vertebral column is derived entirely from the compressibility and elasticity of the intervertebral cartilages, and a knowledge of their three dimensions—namely, their length, breadth, and thickness—is necessary in order to enable us to estimate the relative flexibility of the cervical, lumbar, and dorsal regions. In the first column of the table, we see that the height of

		M. M.
The cervical cartilages is	.... =	20·7
The dorsal ditto	.... =	34·9
The lumbar ditto	.... =	42·85

and the mean diameter of the

Cervical	=	15·0
Dorsal	=	25·3
Lumbar	=	28·0

Therefore, if we assume the breadth of the cervical, dorsal, and lumbar cartilages to be equal to their length, the surface of their horizontal sections in millimeters will be nearly as—

Cervical.		Dorsal.		Lumbar.
225	:	640	:	784

so that when the cervical, dorsal, and lumbar portions of the vertebral column are curved with equal force, their angles of flexion due to the elasticity of their cartilages will be nearly as—

$$\left.\frac{\overline{20\cdot 7}}{225}\right|^{2} : \left.\frac{\overline{34\cdot 9}}{640}\right|^{2} : \left.\frac{\overline{42\cdot 8}}{784}\right|^{2} = 846 : 297 : 298$$

Hence we perceive that, under an equal force, the dorsal and lumbar portions of the spine possess very nearly equal degrees of flexibility, and that the cervical portion has nearly three times the flexibility of either the dorsal or the lumbar. The force exerted on the cartilages of the lower portions of the spine must, however, be often, if not generally, greater than that on the upper, and this will cause the lower dorsal and lumbar cartilages to yield more in proportion to the cervical than is exhibited in the above calculations of MM. Weber; but the increase of flexion from this cause cannot be very great.

Mr. Skey appears to have entirely mistaken the relative degree of flexion of which the spine is susceptible: he observes, that "nature has given to the region of the loins the greater freedom of motion, because that portion of the body is midway between the head

and feet;"* and, in certain positions, this tends, as he supposes, to give the body greater stability. Now, not only has the lumbar region the least power of motion in the whole column, but a greater mobility would have tended to render the movements of the superincumbent part unstable, and a person in such a predicament would be what is vulgarly termed *top-heavy*.

Mr. Harrison, on the contrary, has stated that motion is more limited in the dorsal than in either the cervical or the lumbar vertebræ. We find, however, from the above calculations, that the flexibility of the lumbar and of the dorsal vertebræ is very nearly equal. The intervertebral cartilages would permit the bones to move freely upon them, but the quantity, as well as the direction, of the movements of the several vertebræ is limited by the oblique processes, and by ligaments of the vertebræ placed obliquely.

Ligaments of the Spine.—The ligaments of the spine perform very important functions. It is well known that they serve to keep the vertebræ linked together in a continuous chain, and they also determine the limits of their motions upon each other. Among the ligaments of the spinal column, the functions of those which connect the head with the atlas and dentata are of a more active kind than those of the succeeding vertebræ. The ligaments of the spine possess great strength, and, in robust persons, are endowed with

* Skey on a New Operation for Lateral Curvature, p. 6.

considerable elasticity. On the other hand, in persons of weak and relaxed constitution, their strength as well their elasticity is often much impaired; for they admit of being stretched with much less force, and do not contract again with so much energy as in a healthy state.

In the erect position of the body, the ligaments of the spine are in the state of least action, as are also the muscles, because in that position no stretching force is exerted either on the oblique articulating processes, or on the bodies of the vertebræ, and therefore the ligaments must be in a state of repose. The crucial ligaments being, as their name implies, attached to the bodies, prevent their too great motion on the intervertebral cartilages, and also the too great horizontal or spiral movement of several of the vertebræ on each other—a movement which would endanger the integrity of the capsular ligaments of the oblique articulating processes. The anterior and posterior spinal ligaments, like the cervical, connect the bodies of the vertebræ with each other, and limit the bending of the spine backwards. These ligaments are of great strength; which is the more requisite, because there are no bony processes which serve immediately to keep the bodies of the vertebræ from rotating on each other.

Effects of equal and of unequal pressures on the intervertebral substance.—When the trunk has been kept in the erect posture during the day, an adult man, of middle stature, loses about one inch of his height, which he does not regain until after having remained

some hours in a recumbent position. Six or eight hours will accomplish this effect, according to ordinary observation; but how much less time will suffice, has not, at least to my knowledge, been accurately ascertained. As the united thickness of the intervertebral substances in an adult man is about 3·875 inches, it must lose nearly one-fourth during the day, and regain it during the night; and if each intervertebral cartilage gained or lost an equal portion, the variation in each would be equivalent to $\frac{3 \cdot 875}{23} = 0 \cdot 168$ of an inch. In consequence, however, of the unequal thickness of these cartilages, this is not an exact estimate. That the intervertebral substance is compressible, and that it does not return to its former state immediately after any long-continued compression, are well-established facts. It differs, therefore, not only in structure, but also in function, from inorganic elastic matter, which returns, after long compression, to its primitive state, when the compressing force is removed.

It has been shown that the normal curves of the vertebral column are due to the unequal heights of the vertebræ and cartilages, and, consequently, every abnormal state of the figure of the spine must result from some change in one or both of these parts. Owing to the special adaptation of the figure, and disposition of the articulating surfaces of the bodies of the vertebræ to those of the intervertebral cartilages, the latter are compressed equally in the erect position only, and it is in that position only that they can sustain the greatest amount of pressure, because the entire force is then

distributed over their whole surface, and each part of the cartilage sustains its proper share of the load; but in every other attitude of the trunk the cartilages are unequally compressed. For example: when any two vertebræ move freely on each other in any direction, forwards, backwards, or laterally, the articulating surfaces of the bodies of the vertebræ, on that side to which the trunk inclines, approach each other, whilst those on the opposite side recede from each other. Hence it is obvious that, whenever the spine is curved in any one direction, some portion of the intervertebral substance bears a larger proportion of the whole compressing force of the superincumbent organs than the rest; and, if such unequal distribution of the force be long maintained, it must tend to derange the functions. We have seen that when the intervertebral cartilages have been subjected to continued pressure, they do not instantaneously recover their primitive condition. From this it may readily be inferred that, if the surface of the cartilage has been unequally acted on by a force applied day after day for some time, it will become so much compressed in one part, and expanded in the opposite, as to assume a new figure, adapted to the abnormal attitude which gave rise to its unequal compression. In fact, it becomes diseased by the influence of simple mechanical compression, independently of other causes. The intervertebral cartilages having thus been made to assume a new figure, occasion deformity of the spine, and are indeed,

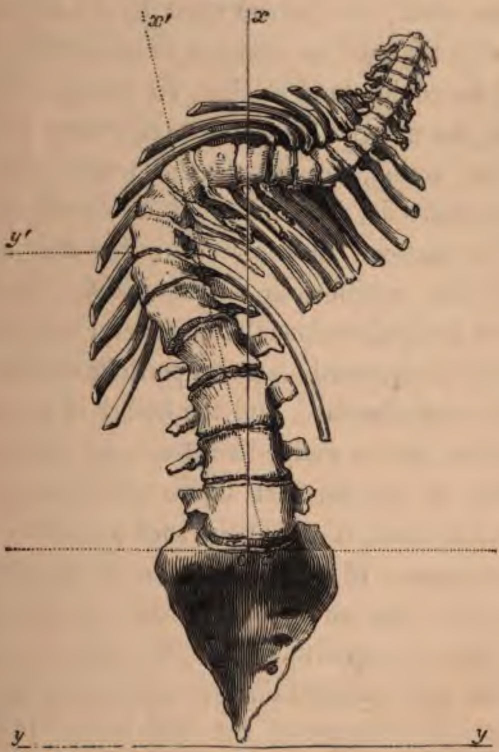
in all probability, the usual seat of lateral distortion, when it is merely of a mechanical character.

Effects of equal and of unequal pressures on the vertebræ.—The bodies of the vertebræ being chiefly composed of reticulated structure, are more yielding, more vascular, and less elastic, than those bones which contain a greater proportion of the earthy constituents common to bone in general. It has been shown that the elasticity of bone varies with the greater or less proportion of the earthy to the animal matter, and that when the latter greatly predominates, the bones lose their elasticity altogether. The persons who are most prone to suffer from distortions of the spine are those in whom the whole osseous system has the least proportion of earthy matter consistent with a healthy though delicate state of constitution. Now, as in such persons the long bones of the legs are scarcely capable of supporting the frame, it naturally follows that the bodies of the vertebræ, having a smaller quantity of earthy matter in their composition than the former, and being consequently weaker, must suffer from the effects of pressure in a still greater degree. In many such persons, while yorng, and growing rapidly, the bodies of the vertebræ, having only a very low degree of elasticity, become compressible, like the intervertebral cartilages, and, like those bodies, when unequally compressed, do not readily regain the normal state. Such persons may therefore become deformed from purely mechanical causes, and this may take place by

an alteration in the figure either of the cartilages, or of the bodies of the vertebræ, or of both. That distortions actually do arise from the causes here assigned, we have abundant opportunities of verifying, by inspecting the condition of the cartilages and bones of many preparations of the vertebral column in anatomical museums.

The annexed figure, for example, is a specimen of lateral curvature of the spine, selected for the purpose, from the Hunterian Museum, and in this case the

Fig. 8.



whole column participates in the distortion. In this figure it will be observed that the articulating surfaces of all the vertebræ, from the last lumbar to the first cervical, except that of y', instead of being perpendicular to the mesial plane, are oblique. It is obvious that depression of the articulating surface of the third and fourth lumbar vertebræ towards the right side, would throw the head into the line x' c', and that a similar depression of the articulating surfaces of any of the superior vertebræ would increase the inclination of the head in the same direction; so that, without great muscular effort, this person must have been unable to stand with the head in either of these several positions, even if he could stand at all. To prevent this waste of force, the muscles on the left side were called into increased action, by which the trunk was drawn towards that side, in order that its centre of gravity might be restored to the vertical line x c, and thus preserve the equilibrium of the body. During this period of unequal action, the bones and cartilages were unequally compressed; certain portions of them on the left side were absorbed, and the bodies of the vertebræ themselves took a wedge-like form, in order to allow the spine to assume that figure which, according to mechanical laws, it ought in such a case to present. In consequence of the magnitude of the dorsal curvature, the ribs on the right side are brought very nearly into juxtaposition with the spine; they must, therefore, have pressed on the respiratory organ, and ded the inflation of the right lung. In this case

there are no traces of serious disease in the spinal column, and the distortion appears to have arisen from the neglect of proper treatment in the early stages of the complaint. It is a case compounded of unequal pressure on the intervertebral cartilages, softening of the bodies of the vertebræ, and, consequently, of unequal muscular action, all arising from a disturbed condition of the mechanical and chemical forces which act on the body in its normal state.

CHAPTER III.

THE MUSCLES.

Muscles; their tonicity or contractility; volume constant in different stages of their contraction; power of muscles; weights of the extensors and flexors compared; muscles have no intrinsic power of elongation; may be elongated mechanically; effects of standing during lengthened periods; effects of change of attitude; powers of extensor and flexor muscles compared.—Quantity of nervous action expended dependent on the nervous system.—Myotomy and Tenotomy.—Paralysis.—Spasm.—Section of muscles and tendons an irrational practice.

THE muscles have long been regarded as one of the causes of distortions of the spine and limbs. It will be desirable, therefore, to investigate how far this hypothesis is consistent with what is known respecting the properties of muscles in repose and action, and the conditions to which they are subjected by elongation and contraction. It is well known to every physiologist, and to every practical surgeon who has paid attention to the subject, that all muscles, when in a state of repose, are also in a state of passive tension, and that, however relaxed they may be by the position of any portion of the body, they will, if cut across, become still more contracted. This property has by some authors been termed *tonicity*, by others, *retrac-*

tility. If a limb be kept constantly bent, and the ends of a set of muscles be kept nearer to each other than they would be when the limb is extended, it is observed that the passive force which is always inherent in living muscles will cause them to diminish in length, and to become permanently contracted. If the flexion of the limb is only temporary, and the repose of the muscles in their new position short, they lose, for that period of repose, only a portion of one of their dimensions,—namely, their length, and gain a proportionate augmentation of their two other dimensions of breadth and depth; for, during the voluntary contractions of muscles, their total volume remains constant. But this applies only to the action of muscles in the healthy movement of the limbs; for if, from any unnatural position of the body and want of exercise, a muscle is kept unduly shortened, it diminishes in depth and breadth, as well as in length, and loses also a portion of its power. The powers of muscles are in proportion to the areas of their corresponding transverse sections, and at the rate of about five hundred pounds for every square inch. According to MM. Prevost and Dumas, the muscles are capable of contracting about 0·23 of their length, or nearly one-fourth, a range which is sufficient to produce all the motions and positions observed in animals. The comparative powers of muscles, according to Borelli, may be thus estimated.

1st. When two muscles are composed of an equal number of fibres, or are of equal thicknesses, but of unequal lengths, they will suspend equal weights; but

their motor powers, and the heights to which they are capable of raising the weights, will be as the lengths of the muscles.

2nd. When the lengths of the muscles are equal, and their thicknesses unequal, their relative powers will depend on the latter; but they will raise weights, proportional to their powers, to equal heights.

3rd. When the lengths and thicknesses of muscles are unequal, the weights which they will raise will depend on their thicknesses, and the heights to which they will raise them will be as their lengths. When the fleshy fibres of a muscle lie parallel to the tendon, the space through which they will draw it is equal to the contraction of the fleshy fibres; but when they are inserted obliquely into the tendon, the space through which they will draw it will vary with their inclination. From the researches of the Professors Weber we learn that the weight of the extensor muscles of the trunk and lower extremities generally predominates over that of the flexors. Their proportions in the legs of two well-formed healthy subjects were found to be as

$$2403{\cdot}2 + \tfrac{1021{\cdot}1}{2} : 810{\cdot}3 + \tfrac{1021{\cdot}1}{2} = 2913{\cdot}75 : 1320{\cdot}85,$$

or as 11 to 5 in favour of the extensors. The weights of those muscles, which perform the double office of flexion and extension, according as either end becomes the fixed point, are halved; but, if these be omitted, the proportion then becomes, 2403·2 : 810·3, or nearly as 3 to 1. The weight of the extensor muscles, when compared with that of the entire leg,

is in the proportion of 5 to 9; when compared with that of the whole of the muscles of the leg, including both extensors and flexors, it is as 3 to 4. Borelli has given approximate values of the powers of a great number of the muscles of the human body, from which we select a few computations, that will convey an idea of the enormous amount of their absolute power, and the large proportion of it which is provided in order to gain velocity. Borelli states that the whole force expended by the muscles of the arm, when stretched horizontally, is 209 times greater than that of any weight suspended at its extremity, and that the force of the biceps, compared with that of the brachialis, is as 3 to 2·6, or as 15 to 13, and their absolute forces as 300 to 260. He estimates the force of the deltoid as 61600 pounds, the sum of the forces of the intercostal muscles at 32040 pounds, and of the glutæi at 375420 pounds. The extensor muscles of the hip, knee, and ankle-joints, have also a large proportion of their power designed to produce velocity.

Such being the law regulating the power of muscles, we need not be surprised that persons labouring under an atrophied state of a limb find it accompanied by extreme debility, arising, not only from vital, but from mechanical causes. It must be borne in mind, that a muscle has the power of contracting to a greater or less extent, but no power of elongating itself. A muscle, however, may be elongated by means of a certain amount of stretching force, if continued a certain period of time, varying according to circumstances. From

these principles we may deduce considerations which are extremely important when applied to the treatment of deformities in general, and especially of those in which the muscles are supposed to exercise any control. In the erect posture, the head, neck, and trunk, with all its appendages, are kept poised on the heads of the femurs by the vigilance of the muscles; and it will be shown that there is no position in which all the muscles acting on the trunk take their proportionate share of action so nearly as when the body is in the perfectly erect attitude. Any movement produced by curving the spine either forwards, backwards, laterally, or obliquely, out of the erect position, tends to elongate one set of muscles, and increase their quantity of action, whilst their opponents are shortened, and deprived of their proper share of action as long as the new position is maintained. It will be shown in a subsequent chapter that the erect position of the body is that in which there is the least expenditure of muscular action; it therefore follows that some of the muscles must act at a mechanical disadvantage whenever placed out of this attitude; but, as any constrained attitude is irksome if much prolonged, a transfer of action from one set of muscles to another is attended with a sensation of ease. For these reasons it is found that standing a long time is attended with a much greater feeling of fatigue than walking at a moderate pace, although the latter requires a far greater expenditure of muscular force. Again, as standing or sitting with the trunk perfectly erect, soon becomes wearisome, the body is often suffered to

bend in some other direction, and very frequently forwards, because in that direction there is a greater feeling of security, and the muscles which extend the trunk are always more powerful than those by which it is flexed. Old persons, who often take but little pedestrian exercise, are observed to oscillate the trunk either backwards and forwards, or laterally, and in this manner alternately transfer the action of one set of muscles to their opponents. This kind of motion being accomplished with little expenditure of force, releases the system, with scarcely any exertion, from the weariness of a continued position in one attitude; and the muscular forces employed in the action and reaction being equal and opposite, no distortion of the figure results. The fatigue experienced after long standing in the erect position appears to have attracted the attention of military men, and to have given rise to the order, "Stand at ease." By this change of position, there is necessarily a transfer of action in the muscular system; but the ease experienced does not arise from this position being that of least muscular action, but from the extensor muscles, which are by far the most powerful, being called into action. It has been shown that the weights of the muscles which extend the trunk and lower extremities greatly predominate over those which bend them; and it is manifest that for equal lengths the transverse sections of the heavier muscles will be greater than those of the lighter, supposing them to be of equal density, and of equal lengths of tendon; and consequently the powers of the heavier

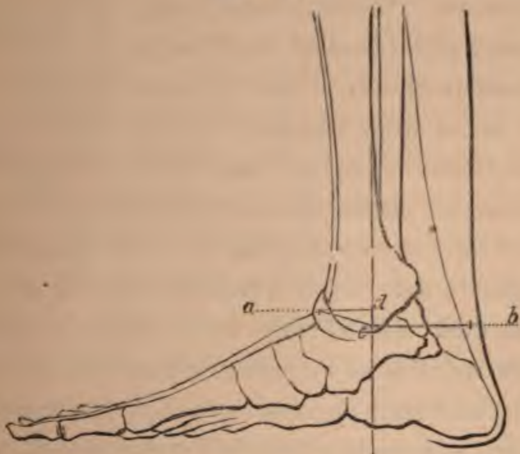
muscles will be proportionably greater. When the whole body is taken into account, the weights of all corresponding parts of persons of similar figure are as the cubes of their heights; but since the power of the muscles to raise a given weight depends on the number of their fibres, their force must vary in the ratio of their transverse sections; that is, as the square of the heights of the persons. From this we see why the strength of persons does not increase in proportion to their bulk; for, if the weight of the person increases as the cube, and the muscular power as the square, it follows that the weight increases much more rapidly than the power, and consequently a small man is stronger, in proportion to his size, than a large one.* The powers of the extensor and flexor muscles of the limbs are always unequal; and in most instances, except in the case of the forearm and hand, the extensors are not only stronger, but also act at a greater mechanical advantage. Such is the case with the muscles which act on the hip, knee, and ankle-joints, in which the distance of the force of the extensors from the axes of motion is greater than that of the flexors.

Fig. 9.

* This is Straus-Durckheim's view, but it only applies to the production of motion, without reference to its quantity.

For example: in the knee-joint, (fig. 9), *a c*, the distance of the direction of the force of the extensors from the axis of motion *c*, is greater than that of the flexors *b c*; and, in like manner, in the ankle-joint (fig. 10), *b c* is greater than *a d*.

Fig. 10.



From these considerations it may easily be seen, that a balance between the powers of muscles cannot be maintained by these muscles alone, and that the limbs can be kept in a state of equilibrium only through the agency of the nervous system; but how the nervous force is directed to keep the different parts in equilibrium is hitherto unknown. Independently of the mere functional contraction of muscles, already described, arising from the nearer approximation of their points of insertion, they may also be contracted either by spasm or paralysis, and distortions may be the result. When the spinal cord is the seat of irritation, the effect pro-

duced on the muscular system depends on the position of the parts irritated. If the motor column of the cord be transiently compressed in any portion of its length, spasmodic contractions of the muscles connected with that part take place; but if it be compressed permanently, paralysis, accompanied by deformity, is the consequence. When the contraction is spasmodic, as in cramps and transient local irritation, the deformity produced is always in the opposite direction to that which arises from paralysis, and the proper treatment of the disease is, in like manner, of an opposite kind. In spasm, the contracted muscles violently overcome the force of their opponents; and the effect upon the limbs is similar to that which is produced by the same muscles in their normal state, but in excess. When the muscles are affected by paralysis, they lose their normal powers, and their opponents, being unresisted, draw the limbs in a manner directly the reverse of what takes place in the former case; so that different affections of the same nerves may produce opposite distorted conditions. Some authors have imagined that distortions of the spine arise primarily from irritation of the spinal cord; but a careful investigation of cases tends to show that the spinal irritation is more usually the effect than the cause of distortion. If the irritation be in the posterior column of the spinal cord, the disturbance of the nervous system is greater, and the effect on the muscular system less; and our diagnosis of these complaints ought manifestly to be founded on a knowledge of the influence exercised by the several

portions of the spinal cord on the muscular and sentient systems.

MYOTOMY AND TENOTOMY.

It has been stated that a contracted condition of the muscles may arise from three different causes; the first mechanical, depending on abnormal attitudes, and occupations tending to disturb the relative proportions of muscular action in different parts of the body;—the second depending on deranged action of the spino-cerebral system, inducing spasmodic contraction of the muscles; —the third depending on a diseased state of the spino-cerebral system, producing a paralytic condition of the muscles. Hence it is evident that, as the causes of deformity are essentially distinct in their character, the remedies cannot be of one kind. Those cases of muscular contraction which depend on mechanical causes require mechanical means of treatment. Among the various methods proposed for this purpose, let us first consider the objects sought to be obtained by the operations of myotomy and tenotomy, and the effects really produced by them. Surgeons, more especially of the German and French schools, finding it difficult to stretch contracted muscles, have adopted the plan of cutting through the muscles themselves or their tendons. By this means the parts held by the muscle are released, and it is found that after a longer or shorter time the fleshy or tendinous portions re-unite, although the points of attachment are at a greater distance than they were before the operation; they

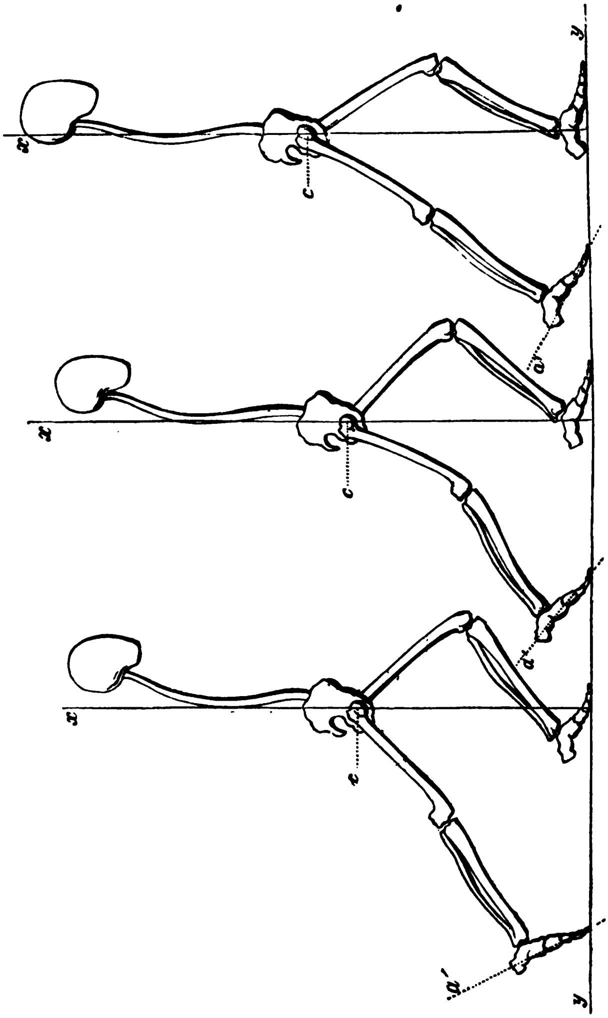
have therefore become elongated. When the tendon of a muscle is divided, the instant the section is completed the segments recede from each other with great force; the interval between the divided parts depending on the length of the muscle, and the distance between its points of attachment after the operation. This is deducible from the theory of Borelli, Prévost, and Dumas, and is also known by experience.

It may readily be understood how the divided portions of tendons are separated, but by what process they are again united with elastic fibrous tissue is not very easily demonstrated. In the Pathological Collection of the Royal College of Surgeons there is only one case (which was presented by Mr. Tamplin) of divided tendons having been united with true tendinous fibrous tissue. It is probable that the tendon recovers its original strength, but not so the muscle; at least, such is the opinion of many of the French surgeons, who say that the muscle so mutilated loses a portion of its force. This may easily be understood to be the case from the experiments of Schwann, who observed that the force of a muscle is at a maximum when it is in its greatest elongation, and at a minimum when it is in its greatest contraction; so that the forces of muscles, in different stages of their contraction, vary in some way directly as their lengths. Now, as the muscles, after their division, become shortened, and have no power to elongate themselves, their union must take place by the production of new matter, which fills up the interval between the divided parts. By this means the muscles are lengthened

without being stretched, and do not acquire the tonicity and extension of their normal state; and hence their loss of power. Malgaigne relates a case in which a corpulent man, while dancing, ruptured the tendo-achillis, and on the next day, before he was subjected to surgical treatment, walked six miles, though with pain and difficulty. He remarks that now myotomy is become as common as the opening of an abscess, and is employed, not only in club-foot, but also for fractures, dislocations, contractions, &c. It is a point of great importance to ascertain the effect of the division of the tendo-achillis on progression. It is said that a person can walk after the tendo-achillis has been lengthened by the operation of tenotomy, an inch and a half or two inches; but Malgaigne observes that the question is, not whether they *can* walk under such circumstances, but *how* they walk. If the attention is directed to the action of the foot in walking, it will be observed that the heel is raised by the tendo-achillis in slow walking, as in fig. 11; in quick walking, as in fig. 12; and in quickest walking, as in fig. 13. In each of these cases, the length of the step is proportioned to the elevation of the heel, and therefore, if after the operation the muscles which raise the heel are too long, the power of the legs in progression will be unequal, the speed will be diminished, and the gait in walking will be altered. Such is the effect of an over-elongated state of the extensor muscles of the foot.

In memoirs read before the Académie Royale de

Fig. 11. Fig. 12. Fig. 13.



Scale :—One-twentieth the natural size ; drawn with the assistance of a modified form of the stroboscope.

Médecine de Paris, M. Guérin stated that he had divided at a sitting forty-two tendons and muscles, in a young man aged twenty-two ; and in a young girl he divided at one time thirteen tendons : he also made

a statistical return of 155 patients treated for deformities by him at the Hôpital des Enfans Malades, of whom twenty-four were completely cured, twenty-eight relieved, four not relieved, one dead, and ninety-eight either under treatment or lost sight of. He stated that he had made 500 subcutaneous sections without producing any inflammatory action, or other injury, and that he had obtained the most satisfactory results from dividing the sacro-lumbalis and longissimus dorsi muscles, in curvatures of the spine. In order to ascertain the truth of these statements, Malgaigne investigated the condition of the patients placed under M. Guérin's treatment; and in a memorial addressed to the Academy* reported that, of the twenty-four cases described as convalescent, he could not find one that was permanently cured; that others, instead of being improved by the operation, were decidedly injured; and he detailed the cases in which this had occurred. This provoked a discussion in the Academy, of a violent and acrimonious character, and a commission was appointed to investigate the matter. The surgeons who were charged with this inquiry reported that the statements of Malgaigne were very exact, that M. Guérin had not succeeded in completely curing curvatures of the spine, and that spinal myotomy would prove a useless, if not a dangerous method of

* Mémoire sur la valeur réelle de l'Orthopédie, et spécialement de la Myotomie rachidienne dans le traitement des déviations latérales de l'épine: par M. Malgaigne.—Comptes Rendus, tom. xiii. 15 Avril, 1844.

treatment. They stated, moreover, that they had never witnessed any good effects from dorsal myotomy.*

Malgaigne and Bouvier† contend that not only is the division of the sacro-lumbalis and longissimus dorsi muscles not attended with any advantages, but the latter, on the contrary, maintained, very rationally, that the muscles in question are constantly required for the movements of the trunk, and that there is no advantage to be gained by their section which cannot be obtained by other means,—an opinion which ought to meet with the concurrence of every practical surgeon pretending to scientific attainments. An opposite view, however, is taken by some who recommend the division of the tendinous portion of the sacro-lumbalis and longissimus dorsi, for the relief of lateral curvatures of the spine; although one of them (Mr. Skey) appears to be well aware that the contraction of these muscles is the effect, and not the cause of the mischief, and therefore very properly mistrusts the utility of the operation in the majority of cases.

To prove the utility of the subcutaneous section of muscles and tendons, it is not enough to show that the

* Guérin still maintains that there is an advantage in the operation of myotomy in lateral curvature of the spine, and contends that the authorities of Messrs. Braid, Whitehead, Laycock, Child, Cocks, Robert Hunter, in England, and MM. Klein, Nieumann, Dieffenbach, Haller, Hein, and Behrend, in Germany, are quite sufficient to balance that of Malgaigne.

‡ Archiv. Gén. de Méd., Août 4, 1843.

operation may be performed with little pain, and trifling danger; although the truth is, that it is not so free from danger as Guérin and others suppose. The posterior tibial artery has been wounded in dividing the tendo-achillis, and the internal plantar artery in dividing the plantar fascia. In both cases abscesses formed, and it was ultimately found necessary to tie the arteries. A case showing the danger of cutting paralysed muscles is recorded by Mr. B. Phillips;—namely, that of a girl aged eleven years, who was paralysed, and had all her limbs contracted, but was able to balance the trunk, and rotate it backwards, forwards, and sideways. Mr. Phillips says, that Malgaigne,* following the example of others, cut the refractory tendon, when all the limbs became straight and rigid, like an iron bar, with the arms lying close to the trunk. The child lay on her bed like a corpse, the head alone retaining the power of moving, and was consequently deprived of those limited movements which she previously enjoyed.

The Académie Royale de Médécine presented to MM. Stromeyer and Dieffenbach the sum of 5,000 francs; to the first, for having executed the operation for strabismus on the dead subject, and to the second, for having successfully practised it on living persons. It would be more desirable to offer double that sum

* Sur l'abus et le danger des sections tendineuses et musculaires dans le traitement de certaines difformités. (Extrait d'une note de M. Malgaigne).—Comptes Rendus de l'Académie des Sciences. Paris, 19 Février, 1844.

for the discovery of the means of curing strabismus without the section of muscles and tendons; and we ought not to despair of attaining this end, seeing that the present practice is directed against effects, or at least against secondary instead of primary causes.

As muscles are incapable of elongating themselves, and, although they oppose great resistance to being stretched, are nevertheless susceptible of elongation, it becomes an important subject of inquiry whether some mode of producing this effect may not be practicable, without the necessity of subcutaneous sections. If a muscle is stretched by any force for a short period, it becomes contracted again as soon as the force is removed; but if the force is long applied, the muscle will not regain its primitive condition until after a lapse of time of greater or less duration, to be determined by future experiment. Now there are, it is true, some organs so constituted, and some muscles so situated, that it is either difficult or impossible to apply a force sufficient to effect the object in view. Amongst the difficult but not impossible cases may be mentioned that of torticollis, in which the sterno-mastoid muscle offers a considerable resistance to any stretching force that can be conveniently applied: amongst the impossible cases may be ranked strabismus, in which myotomy is at present found necessary, because the texture of the eye precludes the application of any force to it. When, however, the contracted muscles are situated in the back and lower extremities, we have ample means of promoting their extension; and in these cases, what

excuse is there for dividing muscles and tendons which are only contracted mechanically? Is it rational to do this merely to lengthen them, when it is found that the same end can be accomplished by other and simpler means?*

When muscular irritation arises from some disturbance of the nervous system, to make a section of the affected muscles is obviously to attack the *effect*, and not the *cause* of the malady, and from such practice no good can be expected. In cases of partial paralysis of the limbs, the contracted side is always the healthy one, the partial contraction being occasioned by the loss of power in the muscles of the other side. If under such circumstances the healthy muscles be divided, as their opponents have lost their power, it is quite clear that the limb thus maltreated must, at least for some time, be motionless; and to divide the muscles on the paralysed side would be still more absurd. In a paralytic girl aged fourteen years, Guérin cut twenty tendons, and these mutilations were only terminated by the resistance of the patient; but, according to Malgaigne, no relief followed the operation; the deformity remained as great as before, added to which, pains in both knees, about the level of the section, supervened, and the patient was deprived of the power of using her needle.

On a careful and rigid examination of the subject of

* Dr. Little recommends that when a muscle is too long, a portion of it should be cut out, and that when it is too short, it should be cut through.—*See* LANCET.

myotomy and tenotomy, it appears that these operations cannot, in the majority of cases, be deemed expedient for the purpose of curing deformities, as nothing can be obtained from them which may not be effected by other and less objectionable means. The excepted cases, if any really exist, are strabismus, and other analogous affections; but even these are to be regarded with great suspicion. The best surgeons of the French school have already decided against the practice, and few of our most eminent English surgeons adopt this empirical plan of mutilating the body.

CHAPTER IV.

MECHANICAL CAUSES OF DISTORTION.

Effects of occupation.—Lateral curvatures of the spine referrible to the necessity of the body obeying the laws of equilibrium, and movements of bodies in general.—D'Alembert's principle. Position of the centre of gravity determined; solution of the problem of the maximum base of support in a given position; effects of weight on the attitudes of the body; effects of the use of the common wooden leg, and also of the improved wooden leg.

Amongst the numerous occupations tending to distort the spine, may be mentioned those of watermen, waiters, harp-players, porters, and the London milk-men; to which may be added, unequal lengths of leg, wooden legs, crutches, &c. In almost all cases of lateral curvature resulting from mechanical causes, the altered form of the spine arises from the necessity that exists for the maintenance of equilibrium in all parts of the body under every change of posture, or application of extraneous force. All attempts to restore the figure by any other method than that of counteracting the disturbing force that has given rise to the deformity, must therefore necessarily fail. This being the principle on which the theory of the causes and treatment of such distortions is founded, we should endeavour to

obtain a clear notion of the conditions requisite for the equilibrium of the body under different circumstances. The various attitudes which the several parts of the body are compelled to assume in order to keep it in a state of equilibrium in different positions, are all referrible to the place of the centre of gravity, which must always be situated in a vertical line, passing within the base of support. If this fact, together with the effects of extraneous forces acting on the body, had been sufficiently studied by surgeons generally, the methods now adopted for the cure of distortions of the spine would never have been introduced.

When the body is acted on by any extraneous force or forces, the conditions necessary for a state of equilibrium are comprised in the following theorem.* In whatever manner several bodies forming a system change their motions, if we conceive that the motion which each body, were it quite free, would have in the succeeding instant is decomposed into two others, of which one is the motion which it really takes in consequence of the mutual actions of the whole system, the second must be such that if each body were impelled by this force alone (that is, by the force which would produce this second motion), all the bodies would remain in equilibrio. To find the distance of the head

* This is the celebrated principle of D'Alembert, by means of which all questions of motion are reduced to those of equilibrium. It supplies a direct method of throwing dynamical problems into equations, and the difficulty is thus reduced to the solving of problems in pure mathematics.

and feet from the centre of gravity of the human body in a horizontal position, it is merely necessary to balance the body placed upon a plane *a b*, on a triangular prism

Fig. 14.

d e, as in fig. 14; then draw a line on the plane close to the edge of the prism; again balance the body in another position, and draw a line as before: the vertical line passing through *c*, the point of intersection of these lines will pass through the centre of gravity. After the plan of Borelli, Weber balanced a plank across a horizontal edge, and stretched upon it the body of a living man: and when the whole was in a state of equilibrium (in which the method of double weighing was adopted), he found, by accurate measurements, the total length of the body—

millimetres		inches.
1669·2	=	65·716404

The distance of the centre of gravity below the vertex—

m.m.		in.
721·5	=	28·405455.

Above the sole of the foot—

m.m.		in.
947·7	=	37·310949.

Above the transverse axis of the hip-joints—

m.m.		in.
87·7	=	3·4547729.

Above the promontory of the sacrum—

m.m.	inches.
8·7 =	0·341519.

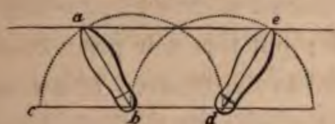
As the horizontal plane of the centre of gravity lies between three-tenths and four-tenths of an inch above the promontory of the sacrum, it must traverse the sacro-lumbar articulation, which is also intersected by the mesial plane, because the body is laterally symmetrical; but, in order to determine exactly the position of this centre, MM. Weber balanced the body on the edge of a triangular prism in the erect posture, and let fall a plumb-line on each side, immediately over the prism, as seen in fig. 15. In this manner they

Fig. 15.

found that the plane meeting the two plumb-lines would, like the two former planes, intersect the sacro-lumbar articulation; and consequently, the point where the two former planes meet the latter is the centre of gravity in man. It will also be observed that the plane meeting the plumb-lines bisects simultaneously the occipito-atlantic, the sacro-lumbar, the hip, knee, and ankle-joints, and that consequently all the corresponding parts of the body are balanced upon the axes of their respective joints, and must therefore be in a state of equilibrium, wherein the least amount of muscular action is sufficient for their support. When a man stands erect, a plumb-line passing through his centre

of gravity will fall between his feet. It is a subject of mathematical investigation, when the feet are equally advanced and equally inclined, as in fig. 16, to determine the angle *a b c*, which they must form with the

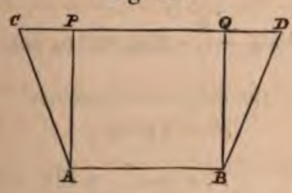
Fig. 16.



prolongation of the line joining the heels in order to afford the greatest base of support. In general, where the legs are perfectly vertical it will be found that the line joining the centre of the heels is just equal to the length of the foot, and in this case the required angle will be 60° exactly. As the heels approach each other, this angle diminishes; and, when they are close together, it is reduced to nearly 45°.*

* It is evident that, if it were required to find the greatest base to oppose an overthrow from behind in the mesial plane, the feet must be at right angles to *b d*, and if to prevent a lateral overthrow, the feet must be in the line *b d*, produced each way. Hence it must be understood, that the maximum base found above is not always the most advantageous position to withstand a shock in one given direction.

Fig. 17.



Let $AB = AC = a$, $AP = x$, $\therefore CP = \sqrt{a^2 - x^2}$ To

Effects of attitudes.—In all persons, but more especially in those who have a delicate constitution, the act of standing for lengthened periods in the erect posture is accompanied by a sense of weariness, and a new position is sought, which gives ease by the transfer of action from one set of muscles to another, as explained in Chapter III.; but this new position is such as often to be prejudicial to the figure. If, for instance, one of the legs is bent, the weight of the body is transferred to the other. To effect this, the trunk is rested upon the hip-joint of the supporting leg; for which purpose the pelvis must be inclined, so that the line passing through

find the angle $A\ C\ P$ when the area $A\ B\ C\ D$ is a maximum.

$$A\,B\,C\,D = 2\,\Delta\,A\,C\,P + P\,B$$

$$= x\,.\,\sqrt{a^2 - x^2} + a\,x$$

$$d\ .\ \text{Area} = d\,x\sqrt{a^2 - x^2} - \frac{x^2\,d\,x}{\sqrt{a^2 - x^2}} + a\,d\,x$$

$$\frac{d\,.\,\text{Area}}{d\,x} = \sqrt{a^2 - x^2} - \frac{x^2}{\sqrt{a^2 - x^2}} + a = o, \text{ when the area is a maximum.}$$

$$a^2 - x^2 - x^2 + a\,\sqrt{a^2 - x^2} = o,$$

$$\therefore 2\,x^2 - a^2 = a\,\sqrt{a^2 - x^2}$$

$$\therefore 4\,x^4 - 4\,a^2\,x^2 + a^4 = a^4 - a^2\,x^2$$

$$\therefore 4\,x^4 = 3\,a^2\,x^2 \text{ or } x^2 = a^2\,\frac{3}{4},$$

$$\therefore x = a\,\frac{\sqrt{3}}{2} = \text{Sin. } 60^\circ \text{ to rad. } a.$$

If A, B, coincide, the expression becomes

$$a^2 - 2\,x^2 = o$$

$$\therefore\ x = \frac{a}{\sqrt{2}} = \text{Sin. } 45^\circ.$$

the axis of the hip-joints, instead of being parallel, becomes oblique to the horizon, and the whole trunk must so accommodate itself to this new position as to bring all parts into a state of equilibrium; otherwise the person would fall to the ground. This attitude, which is so commonly assumed by young and delicate females, produces unequal pressure on the bones of the spine, and the intervertebral cartilages; and, if continued for a long time, or frequently repeated, ultimately causes distortion, as shown in Chapter II. The protrusion of the hip-joint, the unequal height of the shoulder-joints, and the curved state of the spine, are effects which ought to be noticed and corrected before any bad consequences result. The mechanical analysis of the effects of standing on one leg will be given when the cases of unequal lengths of legs come to be investigated.

Effects of carrying weights on the head.—In Professor Andrey's "Orthopædia," published in 1723, we find the following plan recommended:—In order to induce a child to keep the head erect, "Lay upon the fore-part of the head anything that will easily fall off, such as a powder-box, or the like, and desire him to walk so as not to let it fall off. This may be made a sort of play to him, which he should frequently repeat; and it will be proper to reward him when he does right, by way of encouragement. Thus you will soon see the child hold his head upright; but you must conceal your design from him, if possible, which will make it succeed the better. It will be proper to have several

children engaged in the same pastime, to raise an emulation among them, who shall do it. Children, when they are grown up, play at different sorts of games; propose this to them gravely, and tell them that the law of this game is, that whoever lets the box fall shall forfeit a pledge, which cannot be recovered again without undergoing a certain penalty, in the same manner as is usually done in other games. Thus, the child, by playing at this game frequently, will very soon acquire a habit of keeping his head straight." Milkmaids who are accustomed to carry a pail nearly full of milk on their heads, and are proverbially upright, have been adduced by different authors as illustrations of the good effects produced by this method; but the real benefit is undoubtedly owing, not to the circumstance of carrying the weight, but to the necessity of maintaining a certain attitude, in order to prevent its falling; for we have seen in Chapter II. that not only would any additional weight be injurious, but even the natural burden which the spine has to support—namely, the head, &c., tends to increase the distortion. Notwithstanding the advantage of carrying something on the head to correct a bad attitude acquired by standing awry, lounging, and other similar practices, it must be done with discrimination; for there are many delicate females who would soon become fatigued in so constrained a posture, and whenever weariness comes on, the exercise should be suspended. The duration of the exercise must, indeed, always be regulated by the medical adviser, according to the health and strength

of the individual. In all cases accompanied by softening of the bones, the plan is of course inadmissible.

Effects of carrying weights on the back.—When a weight is carried on the upper part of the back, there is a tendency to throw the trunk forwards: for example, when a porter carries a burden, the attitude of the body must be accommodated to the position of the common centres of gravity of himself and his load. In figure 18, let *G* and *L* be the centres of gravity of the man and load, and *g* the common centre of the two; then, in order to bring this common centre into a vertical line passing through the base of support, it is obvious that the man must bend his body for-

Fig. 18.

wards.* In this case, the glutæi muscles regulate the rotation of the trunk about the hip-joints, while the extensor muscles of the trunk prevent the load from bending the spine too much upon itself. Notwithtanding this obvious and inevitable result, we find empirics recommending that lead weights should be carried between the shoulders by delicate females, in order *to stretch the muscles of the back*, and counteract the tendency to incline forwards. But, with such an object, the load should, in fact, be carried in front of the person, which would have the effect, not only of strengthening the muscles of the back, by bringing them into play, but also of throwing the trunk into an erect posture, provided the weight be adjusted to the inclination of the body. The attitude of corpulent persons, and of pregnant women, affords a good illustration of the effect of having the weight in front. But, to be more precise, suppose a weight to be slung from the shoulders in front of the person, so that its

* Let the weight of the man equal W, and that of the load W', $D =$ the length of the line $G\,c$, and $D' =$ the line $L\,l$; then, as all the parts are in a state of equilibrium, we have

$$W\,D = W'\,D'.$$

But when the man walks with the load, the estimation of the force he expends to propel himself and the load forwards, becomes a problem much more difficult to solve than in the above case, that simply of equilibrium while standing in a given attitude. The investigation of this subject will be found in Poisson's "Traité de Mécanique," tom. ii., and in the Messrs. Weber's "Merchanik der Gehwerkzeuge." The latter appear to have 'en the most correct method of viewing the subject.

centre of gravity be far in advance, as in figure 19, and let G and L be the centres of gravity of the body and the load, and g the centre common to the two, as before,—in order that the body may be in an attitude to counteract the weight of the load, it must be thrown backwards. The flexors of the trunk will prevent its too great rotation about the hips, while the ligaments and articulations of the vertebræ preserve the figure of the spine, and counteract the pressure of that portion of the weight which is transmitted to it. Hence it is evident that, as the rotation of the trunk backwards is very limited, compared with its rotation forwards, we cannot support a weight in front anything nearly so great as one on the back. The same principles are applicable when weights act on the body on either side, as when they are placed before or behind; but, instead of the force acting in the mesial plane of the body, it acts perpendicularly to it. Such is the case when a weight is held hanging at the side in one hand, or when it is placed on one shoulder, or slung at the side from the opposite shoulder, as in figure 20.

Fig. 19.

A nursery-maid carrying a child on one arm, is a familiar example of a weight acting laterally. In all

these cases the vertebral column is curved laterally, in order to throw a sufficient portion of the head

Fig. 20.

and upper part of the trunk on that side of the mesial plane which is opposite the side on which the weight acts. By these means the convex side of the curve is on the same side with the load, and consequently the shoulder of the loaded side is also the higher. In the application of exercises with weights, to counteract lateral curvatures of the spine, when the nature of the case renders such a plan admissible, care must always be taken to ascertain the number of the curves, because, as we shall afterwards see, the determination of the part to which the weights should be attached depends on the question whether the sum of such curves is an odd or an even number.

Effects of wooden legs.—When an ordinary wooden leg is substituted for the natural leg, a system of actions is produced very different from that which originally existed. The wooden leg being incapable of movements of extension and contraction like those of the natural leg, the gait of the person in walking is entirely altered, and the centre of gravity describes a very tor-

tuous path. The natural path of the centre of gravity in walking deviates but little from a straight line (See "Cyclopædia of Anatomy and Physiology," Article "Motion"), having, in fact, a slightly undulating motion, both vertically and horizontally. But, when a single wooden leg is substituted, as above mentioned, the effects are as follow:—Suppose the left to be the wooden one, and the person about to take a step by lifting it from the ground, the natural leg being foremost and supporting the trunk, while the end of the wooden leg is at its greatest distance on the ground, if the hinder leg were a natural one it would be flexed as soon as it was raised, in order that, being thus shortened, it might swing freely past the other without any necessity for a lateral inclination of the trunk; but, as in this case it is inflexible, the body must either incline greatly towards the opposite side, to allow the leg to swing past in a nearly vertical plane, or else the end of the leg must describe a curve outside that plane. In either case the centre of gravity is thrown out of its normal course towards the right side. This is obvious from what we have just stated, when the left leg swings forward in a vertical plane, and it is not less true when its extremity describes a curve; for then the weight of the left leg is thrown so far out on the left side, that the equilibrium of the person can be preserved only by inclining his body on the right side. We will now suppose the wooden leg to have swung forwards, and in its turn become the supporting leg. When the right leg is lifted off the ground, it is

flexed, and swings past the left in a nearly vertical plane, but the centre of gravity describes a curve round the end of the wooden leg, and though very slightly deflected from the mesial plane, it is raised very much above its normal position. From this description it is clear that, in such a case, progression is effected by an unequal and dissimilar action of the legs. When the natural leg is the support, we see that there is a considerable deflection of the centre of gravity from the mesial plane, and but little from its ordinary horizontal position, while the contrary takes place when the wooden leg is the support; but these two effects by no means counteract each other, for the whole deflection in both cases is always towards the right side, and therefore must tend to produce distortion.

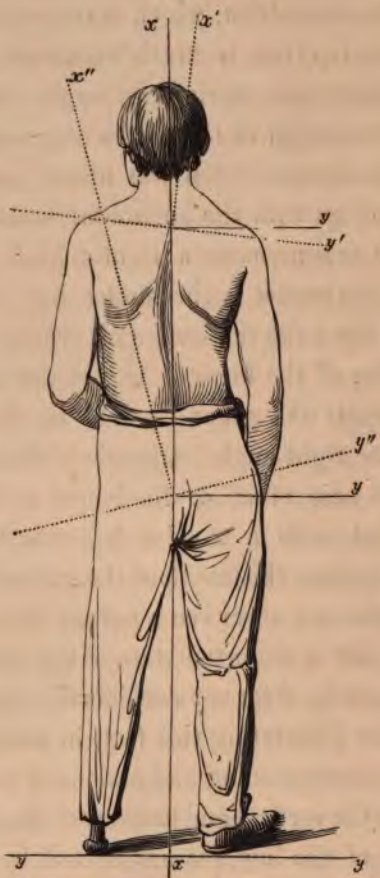
A second cause of deformity exists in the want of force in the wooden leg to propel the body forwards. The right leg begins to urge the trunk onwards by its extension, from the moment the centre of gravity has passed the vertical line through the ankle-joint, and continues to do so until it has attained its maximum elongation; but, when the wooden leg has taken the place of the other, and the centre of gravity has passed the corresponding vertical line, since this leg has no vital force, or power of extension, the body begins to fall down the curve described by its centre of gravity, and continues to fall, till the right leg again reaches the ground. The effect of these unequal actions is to twist the spine about its axis, and thus to throw one shoulder in advance of the other, the right shoulder

being foremost. In addition to this, the right leg always comes to the ground with a spring, but the wooden leg suddenly, so as to inflict on the hip-joint a considerable concussion, which is transmitted to the trunk. The step, too, is much shortened, for in ordinary walking the maximum length of the step depends on the height of the centre of gravity from the ground, at the instant when the hinder leg quits it; since the two legs with the horizontal distance between them form at this moment a right-angled triangle, of which the hypothenuse is the hinder leg. Hence it is obvious that the more the centre of gravity is lowered by the flexion of the forward leg, at the moment the hinder leg quits the ground,—that is, the more the altitude of the right-angled triangle is diminished, the more will the base of it, or the length of the step, be increased; but, with a wooden leg, this cannot take place, and therefore the length of the step is diminished. Hence it is that we never see a person with a wooden leg, who has not a distorted state of the spine, at least after it has been used for any considerable time. Fig. 21 exhibits a case illustrating this fact, in which $x' y'$ and $x'' y''$ are the corresponding inclinations of the hips, and shoulders, to the vertical and horizontal directions x and y. The leg of the boy was amputated by the author of this treatise, a few years ago, on account of a scrofulous affection of the knee-joint, and the boy has been lost sight of until very lately, when the spine presented the appearance given in the figure.

It is clear, therefore, that a better mechanism than

that of the common wooden leg is required to obviate the evils just enumerated. The rich may, it is true,

Fig. 21.



have the advantage of an improved and more expensive kind of wooden leg, in which the power of the bending parts analogous to the knee, ankle, and toes, is so admirably imitated, that no apparent distortion of the trunk is produced. So well, indeed, has this kind of artifi-

cial leg been adapted to perform the motions of the natural one, that it is impossible to discover any difference between them; but, at the same time, the cost of this substitute for the leg is, unhappily, altogether out of the reach of the poor. When we reflect that every person who is obliged to wear the common wooden leg, not only loses the power of quick walking, but becomes deformed, it is a matter of great importance that surgeons should be familiar with these consequences, more especially as it is too much the custom at our hospitals, as well as in private practice, for them to consider their duty at an end when they have amputated the limb, healed the stump, and directed the patient to an instrument-maker. On the contrary, a very important duty still remains to be performed,—namely, that of promoting the future welfare of the patient by prescribing a proper substitute for the natural limb; and the immense funds subscribed for the support of most of our hospitals might surely afford some small allowance to be appropriated for the purpose of supplying poor patients with such improved wooden legs as would enable them to perform all the ordinary occupations of life without difficulty or distortion. This is a subject that army and navy surgeons, more particularly, would do well to take into consideration; since, with the assistance of such a wooden leg, soldiers and sailors might be enabled to discharge most of the common duties of the service, instead of being dependent, as they now are, from the moment they are deprived of a natural leg. When a

person has occasion for the use of two wooden legs, the action being similar on both sides, no deformity of the trunk results, but the base of support at the lower end of the leg is so small, that progression is performed with great hazard of falling. Under these circumstances, the centre of gravity also moves in a series of arcs, instead of in nearly a horizontal line, and the speed is mechanically restricted within much narrower limits than is the case with the natural legs.

CHAPTER V.

MECHANICAL CAUSES OF DISTORTION.

On the use of crutches.—Effects of the use of a single crutch; of two crutches; of anchylosis of the hip- and knee-joints; of unequal lengths of legs; of rowing; of lying in unfavourable positions; and of sitting.

THE CRUTCH.—The common crutch is very frequently substituted for a wooden leg, when one or both legs are either wanting or disabled. When one leg only is thus deficient, persons are very apt to employ only one crutch; and the common crutch, which is either equal to the length of the body measured from the axilla to the ground, or rather longer, is generally used on the affected side to support the body in standing, and in propelling it forwards during progression. It performs, though very imperfectly, the mechanical functions of the natural leg. During the time that the natural leg is lifted from the ground and swings forwards in walking, the whole weight of the body is transmitted to the crutch by means of the axilla, which then becomes the axis on which the body turns; but, when the natural leg is on the ground, the axis on which the body is poised is the head of the femur, and thus the trunk oscillates alternately from the hip-joint on one side to the axilla on the other. It may easily be imagined

that these two actions, so dissimilar and unequal, must seriously affect the form of the body; for, since the centre of gravity cannot under such circumstances move forwards nearly in a straight line, as it ought to do, but must rotate unequally round the two points of support above mentioned, these abnormal actions must tend in a very short time to distort the trunk. When, however, either both legs are affected, or the case is otherwise such that two crutches are employed, the movements of the body are less violent and less contorted, the two crutches neutralizing that portion of each other's action which tends to distort the trunk when only one is used.

In the case where either one leg is cut off, leaving the other sound, or both legs remain, but with impaired functions, so that they are only capable of extension and of supporting the body, when employed together, the act of progression is similar to that already described in a person with two stumps, except that the length of the limb must be regarded as extending from the shoulder-joints, instead of the hip-joints, to the ground. If we observe the action of such a person, we see that whilst he is resting momentarily on his legs, the crutches are rotated from behind him, and placed on the ground in front of the vertical line from the axillæ, the head and neck being thrown forwards to enable the body by the extension of the legs to perform the step, and get again in advance of the crutches; and, in order to prevent the body falling forwards after it has passed the vertical plane through the base of the

crutches, the head and neck are thrown back, and the legs permitted to reach the ground in advance of them; the head and neck are then thrown forwards, and by the combined extension of the trunk and arms the body is brought up into the vertical position, and thereby allows the crutches to be raised and carried on as before. In this case it is clear that the two legs perform the functions of one leg, and the two crutches those of the other; and, since they swing from the shoulder-joints, the step is much longer than in ordinary walking,—a circumstance which accounts for the rapidity with which such persons get over the ground. Where both legs have been amputated, or paralysed, the crutches can be thrown but a little way in front of the body, owing to the absence of the extensor power of the legs, and the steps are in consequence considerably shorter. The only distortion arising from the use of two crutches takes place in the upper part of the spine; whilst, owing to the head and neck being constantly thrown forwards, the convexity is lessened, and the spine itself straightened in the mesial plane.

Anchylosis of the hip-joint.—In cases of disease of the hip-joint tending to anchylosis, the object of the surgeon should be, to prevent as much as possible the shortening of the limb. He must therefore take care that the limb is kept straight, and extended on the trunk, the latter position being most important for the purpose of facilitating locomotion after the joint has become fixed. The necessity of keeping the limb straight has been ably shewn by the late Mr. Aston Key.

A little reflection would naturally suggest this position as the one to be adopted, in consideration of the disadvantages in walking that every other position would entail on the patient ever afterwards. But the person who finds himself deprived of the movements of the hip-joint, little thinks, perhaps, of the serious inconvenience resulting from it until it is too late to be remedied. In the first place, he cannot bend the pelvis on the thigh in stooping; secondly, when sitting, the leg must be thrown downwards on the side of the seat, and when the diseased leg is thrown forwards in walking, the pelvis must rotate on the other hip-joint. Owing to this oscillatory movement, the trunk is twisted spirally; the shoulders turn slightly round its axis; and after a short time the line joining the shoulders, instead of being perpendicular to the mesial plane, is oblique to it. From the operation of the above-mentioned causes, notwithstanding the most judicious management, anchylosis of the hip-joint almost always produces deformity of the spine.

Anchylosis of the knee-joint.—What has been said of the position in which the leg should be kept in a case of anchylosis of the hip-joint, applies also to the knee. When the leg is retained in a straight position during anchylosis of the knee-joint, the limb is afterwards available for the purposes of progression; but, strange to say, this important consideration is very commonly neglected or overlooked by surgeons. The result is, that we daily see persons hobbling about the streets in all directions, with one foot dangling in the

air, in consequence of the surgeon having allowed the knee-joint to become anchylosed in a flexed position of the limb. If the leg is kept straight, it is used in walking without the aid of artificial supports, the effect of the loss of motion in the knee being nearly the same as when the common wooden leg is used, except that the natural leg is capable of motion at the ankle-joint. It cannot, however, lower the centre of gravity in walking, as the sound leg does: hence, as in the case of the wooden leg, the length of the step must be diminished, and there also arises an unequal action of the two legs on the trunk, which must swing laterally, in order to allow the stiff leg to clear the ground; thereby producing distortion. With all these inconveniences, a stiff limb is much better than a wooden one; though, if fixed in a flexed position, it is of less value than a wooden leg, because the person can use the latter in walking, but not the former, without having recourse to additional means of support.*

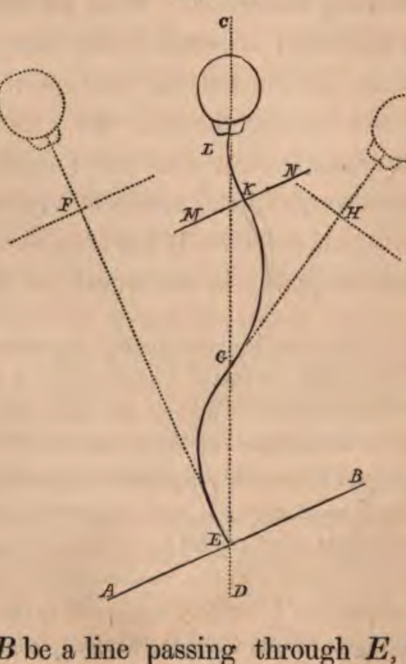
Legs of unequal length.—It has been stated by Dr. Little, that an inequality in the length of the legs is

* M. Bonnet states that, in inflammatory diseases of the knee-joint, "when the most energetic antiphlogistic treatment has failed, and the disease begins to assume an aggravated character, the limb should be straightened and kept immovable by a suitable apparatus. By these means the progress of the disease is arrested, cessation of pain is soon induced, and progressive improvement results. If anchylosis of the joint takes place by the formation and adhesion of false cellular or fibrous membranes, we have seen that the straight position is equally applicable to the production of the most favourable results when mechanically considered."

rarely accompanied with deformity of the spine; but this opinion is contrary to experience, and entirely at variance with the principles which have been advanced in these papers.

The author has had under treatment many persons having their legs of unequal length, and who consequently laboured under spinal distortion, but without any organic disease of the spine; and it is indeed demonstrable from the laws of dynamics that, in order to preserve the equilibrium of the body in such cases, the spine must necessarily be curved. This will appear more clearly from the following illustration.

Fig. 22.



Let *A B* be a line passing through *E*, the junction

of the spine with the sacrum, parallel to the line which joins the heads of the thigh-bones, *C E D* a vertical line, and the points *A B* unequally distant from the horizontal plane, owing to one leg being shorter than the other, or to some similar cause. *E F*, at right angles to *A B*, is the natural position of the spine, viewed from behind, or in front; but, since it would produce a great expenditure of muscular action to maintain it in that position, an effort will be made to diminish the waste of muscular power by supporting the head in the vertical line *C D;* and the process of effecting this will be as follows:—The head will be thrown towards the opposite side of the vertical line, bringing the spine into the position *E G*, by means of the muscles attached to it on the concave side of the curve *E G;* and, if the corresponding muscles on the other side of the spine were inactive, *E G H* would be the very position; but these latter act in a similar manner, and bring the spine into the ultimate line, *E G K*, having the head in the vertical one. In cases of this kind the line *M N*, joining the shoulders, being at right angles to the curved spine, will not be horizontal, unless the point *K* be in the line *C D*.

Fig. 23* represents the case of a young man, aged eighteen years, in whom distortion is produced by the combined effects of unequal lengths, and unequal forces of the legs. From the age of six to fifteen he wore a high-soled shoe, in order to make up the deficiency

* In all the figures where x y, and x' y', occur, x is the vertical and y the horizontal, and x' y' inclined to these directions.

in the length of the left leg, which was the shortest. Subsequently to this period the difference in the length

Fig. 23.

of the legs has been 1·25 inches. The spine presents a single lateral curve, *a b c*, having its convexity towards the left side, the exact of amount of which is shown in Fig. 24, *y*. It will be observed that the left shoulder is the highest, being the same side as that

of the shortest leg. The trunk is thrown towards the right side; the line uniting the hip-joints is inclined upwards, and a line uniting the shoulder-joints downwards, in a direction from left to right; the muscles of the right hip-joint are hypertrophied, and the spine is necessarily curved, in order to preserve the equilibrium of the body in standing. When he walks, the movements of the body are very eccentric. Just before the left leg is about to be placed on the ground,—that is, when the two legs are at that part of the step in which, if they were of equal length, the left foot would be in the act of touching the ground, the right hip-joint, in order to accommodate itself to the shorter leg, and allow it to come to the ground, rolls over obliquely in an arc curved outwards, arrives at its vertex at the moment when the left leg reaches the ground, describes the remainder of the arc while the body is moving forwards, and its weight is transferred to the left leg, and completes the curve, the instant the right foot quits the ground. During this period, the trunk is thrown obliquely on the left side, and the centre of gravity, after being lowered, recovers its position, while the latter portion of the curve is described. In this case, since the longer leg is capable of being flexed, so as to swing past the shorter leg, no particular derangement of the hip-joints takes place; and, when the longer leg becomes the support of the body, the shorter swings forwards into the position above mentioned, just as if both legs were of the same length. When the left foot was placed on a raised

surface, so as to render the line joining the hip-joints horizontal, the head and trunk were thrown towards the left side, and the curvature was partially rectified; but, when a weight of fourteen pounds was placed in the right hand, a new attitude was required to preserve the equilibrium, and the body was still further drawn by the muscles of the left side of the trunk to that side, in order to equipoise the weight in the right hand, and the result was a further diminution of the curve; indeed, the spine then presented an appearance nearly normal, as represented in Fig. 25. The practical deductions which may be drawn from this case are of very great importance with reference to the treatment of deformities of the spine, when arising from mechanical causes, and there will be occasion to notice them in a future chapter, when considering the mechanical treatment of these cases.

Fig. 25. Fig. 24.

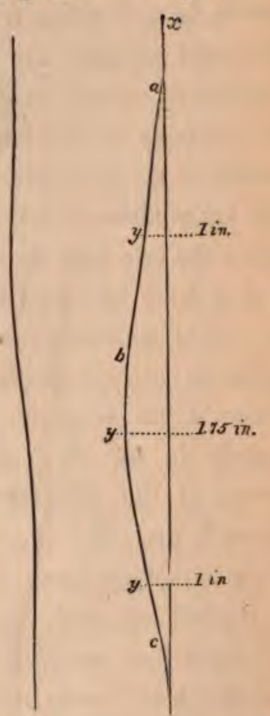
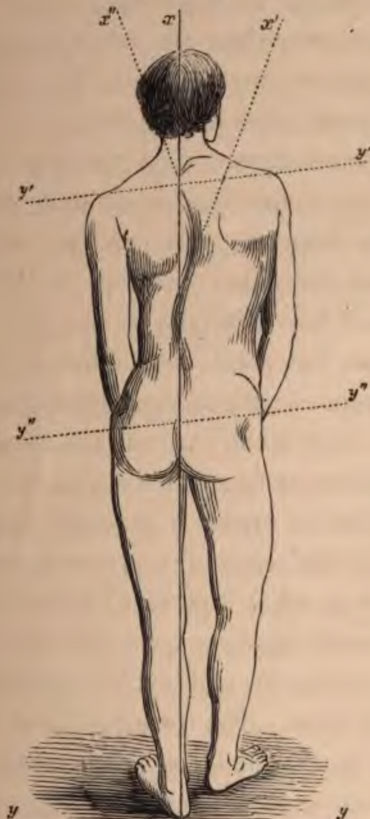


Figure 26 exhibits a case of three lateral curves, arising from the same mechanical causes as those connected with fig. 23. The distortion is represented as it

appeared before any means had been employed for its correction. The patient was a youth of about

Fig. 26.



fifteen years of age, whose legs had been of unequal length from infancy, the right leg being one inch shorter than the left. It will be observed that these curves present the same kind of appearance with respect to the obliquity of the shoulder and hip as the

case of one curve. When one of the lower extremities is curved, the effect is obviously to render the length of one leg less than that of the other. The effect on the trunk is similar to that which occurs when one limb becomes shorter than the other, owing to disease of the hip-joint, or otherwise; and it is gratifying to find that the trunk, after having been so distorted, will resume its normal figure when the leg has become straight. Cases of this kind in children are often presented to the surgeon; the parents very commonly supposing that the spinal curvature is the cause, and not the effect of the deformity in the leg. The tendency to distort the trunk, which has been shown to arise from unequal length of legs, should alone be sufficient to induce surgeons to pay more attention to the subject than they have done; but there are so many other circumstances which render it desirable that the lower limbs should be preserved of a proper figure, that it is surprising how much it has been neglected, and that the most eminent surgeons have thought mechanical support unnecessary for children whose legs have been bent in various ways. The consequence of this neglect has been that the deformity has often remained during life. They seem to have laboured under an erroneous impression, that these curvatures will disappear when the child has grown older, and the bones have become stronger, the fallacy of which hypothesis has been already shown in Chapter I. There are, however, some cases of children in whom the bones become spontaneously straight after the lapse of time, owing to

certain changes in the mechanical and chemical condition of the bones at that period of life. The principles concerned in these cases may easily be deduced from what has been said in the same Chapter.

By inspecting figs. 22, 23, 26, we perceive that, whenever the number of curves is odd, as one or three, the lines which join the shoulder and hip-joints, if produced, will meet on the side of the longer leg, or in other words, the hip of the longer, and shoulder of the shorter leg, are the highest; but, if the number of curves be even, both the hip and shoulder will be the highest on the side of the longer leg. We also find that the difference of only an inch in the lengths of the legs is sufficient to produce a very serious distortion of the trunk.

Rowing.—Rowing has been long observed to be amongst the occupations tending to distort the spine. It is reported that the strongest and best-proportioned men, after having been some time engaged as bargemen in the royal navy, become distorted. The act of rowing is performed by the alternate flexion and extension of the body. The arms are called into violent action, which tends to curve the trunk forwards, but the muscles which extend the trunk oppose the flexure of the spine, and draw the body backwards. These actions tend to exercise and strengthen the muscles of the back, but the compression exerted on the anterior portion of the intervertebral substances and bodies of the vertebræ, causes after a time a partial absorption of those parts, and the spine becomes bent forwards in the mesial plane.

Position of persons lying.—According to the late Mr. John Shaw, "lying on a feather-bed in a curved position of the trunk for lengthened periods, is prejudicial to the figure;" and he remarks, that "the consequence of a long continuance in the position represented in figure 27, must have been observed by those

Fig. 27.

who attend a hospital, as there is scarcely a patient who suffers from the common disease of the hip, whose spine is not curved in this way. This sketch, although it may serve to illustrate the distortion consequent on the disease of the hip, is offered to exhibit one of the causes of the common lateral serpentine curvature of the spine." The view here taken by Mr. Shaw is intended to convey the idea, that distortions coincident with diseases of the hip-joint depend on the position to which the patient is confined in bed, whilst under treatment in our hospitals. Now it has been shown above, that there is always distortion of the trunk in hip-joint cases, whenever the leg on the diseased side has lost any portion of its mechanical power, and the curvature must therefore begin simultaneously with the disease of the hip; but, since these cases are not usually admitted into hospitals until the complaint has passed through its earlier stage, during which the patients have continued to use the defective limb, the distortion has in reality been already produced, although it may have escaped the observation of the surgeon. It is, however, not only probable and consistent with the principles here advanced, but apparently a necessary consequence of the patient being confined to the posture of lying on the healthy side, that the figure of the spine should be altered, unless unequal pressure on it is by some contrivance prevented.

Position of persons sitting.—When a person is sitting on a seat in the ordinary manner, the motion of the trunk backwards or forwards is effected by the

rotation of the tuberosities of the ischia on the plane of the seat. Now any one sitting with the trunk erect soon feels the position exceedingly irksome; and, if there be no support behind, the trunk very soon inclines forwards. The explanation of this tendency is as follows:—In sitting, the trunk is in a position of unstable equilibrium, and the extensor and flexor muscles are in a state of constant action; but, since the flexors are much weaker than the extensors, the body is naturally inclined forwards, by which means the former are relieved at the expense of the latter. Hence it is evident that in sitting the upright position cannot be long maintained without fatigue; but that, by throwing the body forwards, the great power of the extensors enables us to sit for a considerable time without being tired. Parents, governesses, and the masters and mistresses of schools, are constantly ordering young people to sit upright, under a mistaken notion that the flexed posture leads to stooping, whereas it really strengthens the extensor muscles of the back.

CHAPTER VI.

MECHANICAL CAUSES OF DISTORTION.

The body not strictly symmetrical; parts on each side of the mesial plane do not exactly equipoise each other; difference not sufficient, however, to produce distortion.—Mechanical effects of loss of one arm.—Influence of occupation on the figure of the body.—The ribs: horizontal planes touch corresponding portions; conditions of the ribs in spinal curvature; effects of lateral curvature on the ribs; effects of curvature in the mesial plane; figure of ribs in pigeon-breasted persons; effects of distortions of the ribs on the vital functions.—Mechanical functions of the pelvis; pelvis not liable to distortion mechanically.—Distortions of the lower extremities; displacements of the patella.—Mechanical structure of the knee-joint; knock-kneed and bow-legged persons.

The mesial plane is supposed to divide the body in such a manner that the weights of the two sections are equal. It is generally said that the body is symmetrical, but this is not strictly true: yet those organs on either side which are dissimilar both in structure and function may be considered of equal weight; or, if not, the difference cannot be very great, since the external form of most persons presents no apparent deformity, which, according to the principles already advanced, would be the case, if the weight of one side sensibly preponderated over that of the other. In further proof

of this assertion it may be remarked, that the Messrs. Weber balanced the body in different positions for the purpose of ascertaining the centre of gravity, as described in page 77, but did not deem it necessary to test the equality of the weight of its bilateral sections; which their very accurate habits of investigation would doubtless have induced them to do, if there were a degree of inequality sufficient to affect materially the position of that centre.

In consequence of the trunk being a flexible column, it soon begins to assume a new figure, on the unequal addition or subtraction of such weights as sensibly affect the equilibrium of the body. When, for example, an arm has been amputated, the shoulder of the arm which remains becomes elevated, whilst that on the opposite side is depressed, and the spine is in consequence curved laterally. This is owing to the abstraction of the weight of the arm from one side; for, since the arm acts upon the spine at the extremity of a lever of considerable length, and is itself a heavy substance, it is obvious that, if one of the arms be wanting, the head and upper part of the spinal column will naturally be thrown on the deficient side of the mesial plane in order to preserve the balance, and so will produce in time a lateral curvature. It is not, however, an uncommon thing to meet with cases of the loss of one arm, where the shoulder is highest on the deficient side, and we may in such cases reasonably conclude that this phenomenon is the result, either of a previous distortion or of muscular exertion tending to counteract

the opposite weight, or of contraction of the remaining muscles cut through, or of some similar cause.

There is another mechanical effect, which is produced in walking by the loss of one arm. In the natural state, whilst the right leg swings forwards, the trunk is turned horizontally on the head of the left femur, and would propel the right shoulder before the left; but, at the same time, the right arm swings backwards, and the left forwards, by which a force is generated in an opposite direction, and neutralizes the tendency of the trunk to twist horizontally during progression. Now, when a person has lost an arm, this compensating action cannot take place on both sides, and there must consequently result a slight twisting of the trunk, and a perceptible alteration of the gait; but an artificial arm, of the same weight and length as the natural one, would preserve the equilibrium of the trunk without distortion. It should be observed that a deficiency of weight on one side produces the same effect on the position of the shoulders, as a superabundant weight on the other.

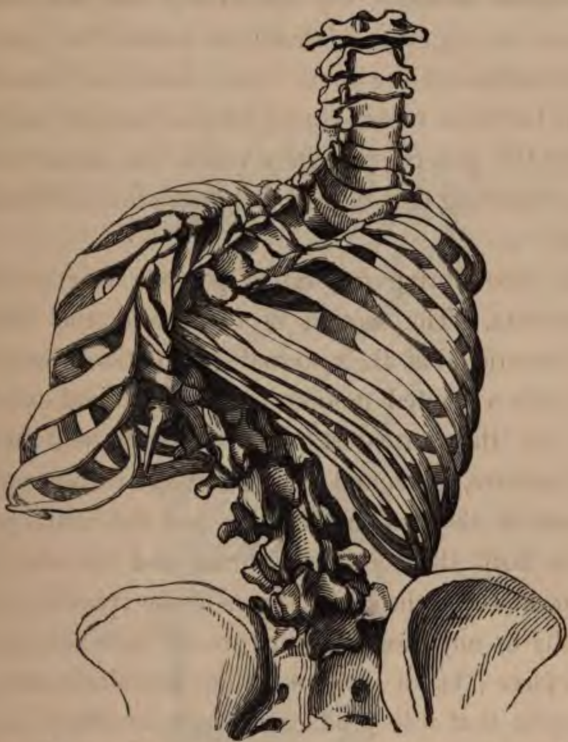
The influence of unequal action on the body is very perceptible in mechanics, and other persons, whose occupations require the right arm to be used more than the left, or *vice versâ*, the muscles on the more active side being always more developed than those on the other. This condition of parts will be found in smiths and others, who use hammers in the right hand only. Needlewomen, who extend the right arm at every stitch,

are subject to a similar deformity. When these occupations require great muscular exertion, the effects on the figure become very apparent; but they rarely assume an aggravated character unless the general health suffers at the same time. Reference has been made to these cases, chiefly for the purpose of illustrating the general principles which the author maintains respecting the origin of distortions from mechanical causes.

The ribs during respiration perform very complex movements. The motion of the seven true ribs is much restricted at their sternal articulations, and they have only a limited motion at their vertebral extremities. In the normal state of the body, and in the erect posture, horizontal planes traverse corresponding portions of the ribs on each side, and the mesial plane bisects both the vertebral column and the sternum. When, however, the dorsal region of the spine is curved laterally in any direction, neither of these conditions takes place; but it is not a trifling lateral curvature of the spine that will produce any serious effects in the relative situation of the ribs. We meet, indeed, with many specimens of such curvature without the ribs shewing in front any visible distortion, the sternum still preserving its normal position; but, if the lateral curvature is of any considerable extent, the ribs must become obviously distorted, owing to their connection with the vertebral column; and in this case they are depressed on the concave, and elevated on the convex

side of the curve, as in fig. 28, wherein it will be

Fig. 28.



observed, that the ribs on the right side descend into the pelvis, whilst those on the left are much elevated above it.

The explanation of these facts is as follows:—

In cases of lateral curvature of the spine to a small extent, the ribs rotate on their vertebral articulations, and being partially fixed at the sternum, are thus preserved from distortion; but, in cases of curvature in the mesial plane arising from absorption of the bodies

of the vertebræ, the ribs immediately partake of the distortion, and the form of the thorax is altered, owing to the attachments of the ribs to the dorsal vertebræ

Fig. 29.

being carried out of their normal positions: as will be seen in figure 29.

When the seven upper ribs on each side do not preserve their usual form, and are less curved than usual, the sides of the thorax present a flattened appearance,

and the sternum is thrown forwards, producing that configuration of the thorax termed pigeon-breasted. This is a species of deformity which may be considered congenital, and depending on the original physical constitution of the individual. In cases of distortions of the spine, especially when the ribs and sternum change their relative positions, there must necessarily be a displacement of many of the viscera; some organs being compressed, others drawn aside, some partially absorbed, and the vital functions carried on with more or less pain and difficulty. In the case represented in Fig. 28, the ribs on the left side approached the vertebral column so nearly that the point of the finger could scarcely be introduced between the two, so that the lung on that side must have been nearly obliterated. When the ribs compress the heart, violent palpitations ensue, accompanied with disordered respiration: in fact, when the degree of distortion is considerable, the disturbance of the vital functions becomes so great that life is not preserved without much suffering and difficulty, and the wonder sometimes is that it is preserved at all. In consequence of the peculiar structure, and perfect adaptation of the several portions which compose the vertebral column, a very great degree of lateral curvature may arise from ordinary mechanical causes, without producing any sensibly injurious effects on the spinal cord; which, indeed, very rarely occur, in the absence of caries, or some other disease of the vertebræ. These cases serve to teach pathologists that the spinal cord may be twisted spirally, or curved in many direc-

tions, without impeding its normal functions. It is not, however, my intention to follow out the subject in this work.

The pelvis presents a structure curiously contrived to fulfil important offices of a mechanical nature in the animal economy. It is endued with lightness and great strength; it affords a large space within, for the lodgment of the internal organs which are well known to be enclosed by it, and a large surface externally, for the attachment of many very powerful muscles. When it is considered that the pelvis has to support a multitude of organs the sum of whose weight is more than half that of the whole body, and to rotate all these parts in various planes without injury, it need not create surprise to find that it is a very admirable piece of mechanism.

By the union of the several bones of which the pelvis is composed, an elastic hoop of unequal depth, breadth, and thickness is formed, which sustains with great firmness the various pressures to which it is subjected, both upwards and downwards. The lateral walls of the pelvis are directed obliquely outwards and upwards, and cut the vertical lines passing through the heads of the femurs, in such a manner that the direction of every percussion on the femur passes through the solid walls of the os innominatum obliquely to its plane: by which means, combined with the partial yielding at the sacrum and the pubes, owing to their being connected by fibro-cartilage, the jarring effects of these percussions are greatly obviated.

The ossa innominata are of considerable strength. Their surfaces are provided with a thick layer of hard laminated osseous structure, enclosing a portion of cancellous texture. The thickness of the latter is augmented, and that of the laminated structure diminished, immediately above the acetabulum, which arrangement tends to diminish the shocks which would attend locomotion if the laminated structure had been continued through the whole substance of the bone. Hence, when a person leaps or falls from a great height, and alights on his legs, shocks which are sufficient to break the neck of the shaft of the femur rarely fracture the pelvis.

The late Mr. John Shaw remarks that the pelvis is not easily distorted in cases of lateral curvature of the spine, or distortion of the ribs, independently of rickets or caries. He also remarks that, in Sandifort's plates of distorted ribs and spine illustrating the contents of the museum attached to the University of Leyden, the pelvis retains the normal figure; and adds, that in Sir Charles Bell's collection the same fact is observable. In all cases of unequal length of the legs, such as those already mentioned, and also in some kinds of distortions of the trunk, the axis on which the pelvis oscillates is oblique to the horizon; and yet, although thereby subjected to unequal pressure, the pelvis preserves its normal figure, for which end its structure is evidently adapted.

The base of support of the pelvis, and of all the superincumbent parts, is on the rounded heads of the

femurs, and the centre of gravity of the body in the erect position lies above the axis of motion. The body would be in a state of unstable equilibrium, if it had the same power of rotating backwards as it has forwards; but this is prevented by a peculiar arrangement of muscles, ligaments, and fasciæ, which obstructs any movement in that direction, and secures the person from falling backwards.

DISTORTIONS OF THE LOWER EXTREMITIES.

Independently of the injurious effects which distortions of the legs, by rendering them of unequal lengths, produce upon the spine (as mentioned in page 85), there are many other circumstances connected with the subject which deserve attention. It is not necessary to dwell on the bad effects of every kind of distortion, exhibited in the awkward gait of persons in walking, and in the destruction of that symmetry which constitutes the perfection of the human figure; but it may be well to observe how few persons there are in society whose legs are sufficiently straight and well formed, to allow of their being clothed so as to exhibit their shape. This is frequently owing to the neglect of their parents, and medical advisers.

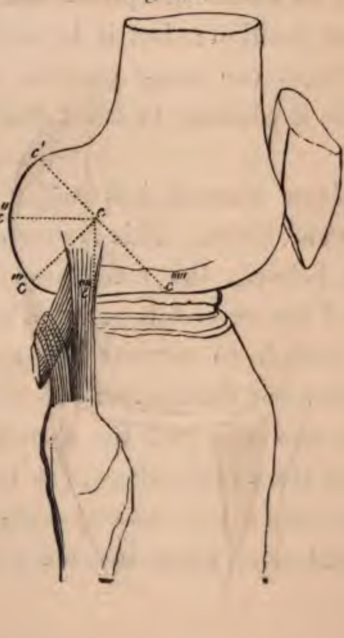
When the legs are bent inwards, so that they strike against each other in walking, the person is called knock-kneed. If the bend is very great, the patella is shifted to one side, and over the external portions of the joint, as in fig. 36. When the legs are bent out-

wards (which is the case with bow-legged people), the patella plays on the inside of the joints. Such are the natural mechanical effects of these curvatures; for the patellæ are not so tied to the knee-joints as to confine their lateral motion, and their axes must therefore lie in the line of the axis of the extensor muscles of the leg. The author has several cases under treatment in which the patella acts either on the inner or outer side of the joint. Now the influence of the muscles in these cases is to increase the distortion of the limbs; because, as they act like the bowstring on the bow, every contraction tends to bend the leg at the knee-joint. Some surgeons, forgetting the cause of this kind of displacement of the patella, have attempted to push the bone into its normal position by a force acting laterally, and, by means of splints and bandages, to keep it in that position; but it is obvious that this plan of treatment can never succeed, and that the only remedy is, if possible, to effect the straightening of the limbs.

The thigh-bone is much less subject to distortion than the tibia and fibula. This depends on the difference existing between the mechanical and chemical constitution of the several bones. When the tibia is not strong enough to support the superincumbent weight, the bone will curve either outwards or inwards, backwards or forwards, and the shaft will very often bend in two or three different ways at the same time; but these last-named cases usually occur in children of very bad constitution, whose bones are often soft and

pliable, and it is in this state of the bones that mechanical support is needed, the reasons for which have been already explained in page 10. In many of these cases of distortion of the legs the shafts of the bones are unaltered, and the deformity is owing to the state of the ligaments of the knee-joint which control the movements of the limbs about it. Such being the case, it will be desirable to inquire into the normal functions of the ligaments in question. In order to examine the true function of each ligament, and the nature of the motion of the condyles of the femur on the head of the tibia, the Messrs. Weber,—from whose labours we derive so much accurate and scientific knowledge of the mechanism of the human body,—instituted a series of experiments, which are detailed in their "Mechanik

Fig. 30.

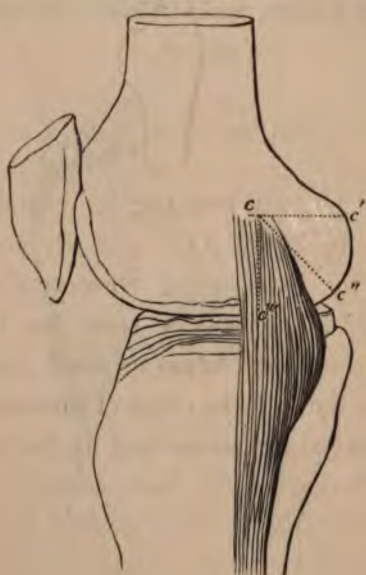


der Menschlichen Gehwerkzeuge," wherein it is stated that the knee is not strictly a ginglymoid joint, because the condyles of the femur do not rotate about a fixed axis; but, whilst they both turn round a common axis, the outer condyle, which is smaller than the inner, slides upon the almost horizontal surface of the head of the tibia. The edge of a section of the external condyle perpendicular to the axis of its rotation is of a spiral form, the pole of which is c', (figure 30) the point of attachment of the external lateral ligament; and of the radii, cc'' is greater than cc', cc''' than cc'', and so on. In consequence of this figure of the condyle, the centre c is lowered during flexion, and is at its maximum height when the limb is fully extended; and for the same reason the external lateral ligament, c'''', is relaxed during flexion, and stretched during extension.

Fig. 31.

The anterior crucial ligament is also relaxed and twisted on itself during flexion, the anterior portion of the ligament being carried backwards, and the posterior forwards, as seen at a' c' in figure 31: the contrary of this occurs during extension. It is this construction of the joint that permits the external condyle to rotate round the internal, or the tibia to revolve on its axis during the flexion of the leg, to the extent of about 39°. The inner condyle is, however, differently circumstanced; the figure of the articulating surface is not like that of the external, and it has a different centre of revolution. The internal lateral ligament cannot be relaxed during flexion like the external, because the radii cc', cc'', &c., figure 32, are very nearly equal.

Fig. 32.



The posterior crucial ligament also, instead of being relaxed during the flexion of the limb, is carried forwards, turns on itself, and is extended, as seen at $c' p'$, figure 33. On the contrary, during extension, it is

Fig. 33.

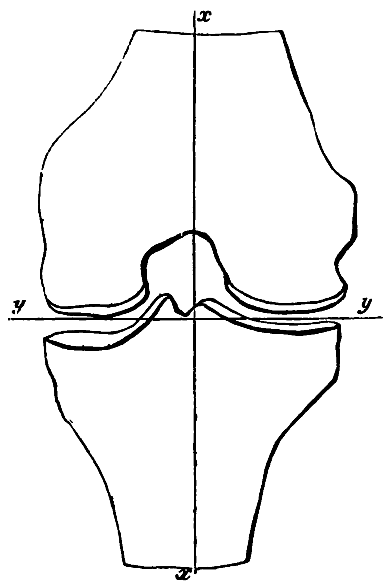
twisted on itself, still retaining its extended state, as will be seen in figure 34 c' a'. By comparing the positions of the letter c' of corresponding parts in figures 33 and 34, it will be seen that the ligament has made a partial revolution on itself during the extension of the limb. The effect of this arrangement is, as before observed, to secure and fix the inner condyle during the flexion of the limb, leaving the external condyle partially free to rotate around it, and allowing a limited amount of pronation and supination.

Fig, 34.

From the preceding remarks it follows, that when the leg is extended, the four ligaments are stretched, and thus the limb becomes stiff enough to support the body firmly in standing: indeed, but for this exquisite piece of mechanism being adjusted in this or some such manner, the limbs could not support the body steadily in walking, and yet have the power of pronation and supination. The capsular ligament of the knee-joint has but little effect in restraining the movements of the condyles; for when the two lateral and the two crucial ligaments are cut through, leaving only the capsular to perform its office, the bones of the joint rock and jerk

on each other at every movement. The semilunar cartilages protect the articular surfaces of the joints from the surrounding tissues, and by their mobility perfect the action of the mechanism. The synovial membranes present an extensive surface for lubricating the joint, and preserve it from friction. If a longitudinal section of the femur and tibia be made through the knee-joint, the articulating surfaces are nearly perpendicular to the axis of the bones, as is seen in figure 35, where *x* is perpendicular to *y*; and it therefore follows, that when

Fig. 35.



the lower part of the limb is vertical, the surfaces of the joint are horizontal; and if a vertical plane parallel to the mesial pass through the centre of the head of the femur, it will likewise bisect the knee and ankle-joints.

This state of the limb must, of course, be considered as its proper normal condition, which being well understood, we are in a position to examine the abnormal states of the joint. One of the most common of these is when the knees either approach or recede from each other too much, and so produce deformity. It has been seen that during the extension of the limb in the normal state of the joint, the internal, lateral, and posterior crucial ligaments are stretched, and that the lower part of the leg is incapable of abduction, adduction, supination, or pronation, It has, in fact, but one direction in which it can move; namely, that of flexion. Now, in those cases where the bones are not diseased, but there is an unnatural bending at the knee, it is obvious that the joint must present some abnormal change. In knock-kneed persons (see fig. 38), the following symptoms may be observed:—The leg during flexion preserves its normal position; but on its being partially extended, the tibia rotates obliquely outwards, and, when fully extended, instead of being perfectly rigid, it rotates laterally; a chink may also be detected between the inner condyle and the head of the tibia. From these phenomena it follows, that in such cases the internal lateral and posterior crucial ligaments must be too much relaxed, so as to admit of the tibia being inclined inwards, and of its rocking. This may arise either from a very imperfect elasticity, or a deficient development of the ligaments, rendering them incapable of performing their proper functions. It also follows that the external condyle must be more

pressed against than the internal,—that is, at the anterior part where the limb is extended, which (as

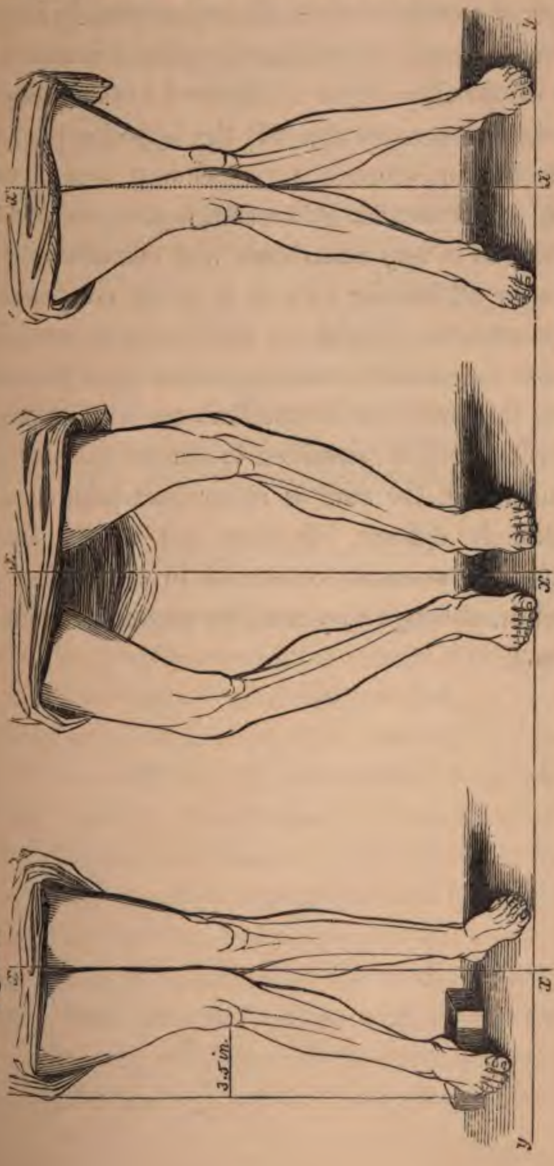


Fig. 36. Fig. 37. Fig. 38.

these cases usually occur in childhood) most probably interferes with the progress of its growth; and hence the inner condyle becomes disproportionately large, and altered in figure, and causes the oblique outward rotation of the tibia which is observed to take place. In bow-legged persons (fig. 37) the opposite phenomena are found, for which a corresponding reason may be given. The peculiar gait accompanying each of these deformities is very remarkable and characteristic; but as we are all familiar with it, it needs no description. Early attention should be paid to these complaints, because they soon become aggravated from the circumstance that every use of the limb tends to increase the distortion; and if permitted to remain uncounteracted till manhood, the cure is either uncertain, or at least exceedingly difficult. It does not appear that the muscles are primarily concerned in originating these disorders, although they tend to augment them when begun.

CHAPTER VII.

MECHANICAL CAUSES OF DISTORTION.

Mechanical and other causes of distortion.—Distortions of the ankle-joint and foot.—Sketch of their normal mechanism in different sections.—Range of motion of the foot.—Action of its muscles.—Demonstration that wrong muscles are often selected for cutting in talipes.—Different theories of club-foot, both congenital and non-congenital.—Malformation and mal-position of the bones.—Contraction of the gastrocnemii muscles, arising from unequal length of legs, resulting in talipes equinus.—Cases of rotatory affections of the feet associated with varus.

THE ANKLE-JOINT AND FOOT.

When the structure of the human ankle-joint and foot is examined with reference to the functions of these parts, both in supporting and propelling the body, it is found to be a piece of mechanism most perfectly adapted to its office, and calculated to excite a degree of admiration fully equal to that which is invariably produced by an attentive examination of the structure of the hand. When a person stands upright, the tibia rests on the highest portion of the articulating surface of the astragalus; and in order that the erect position may be maintained, and any lateral rotation on the astragalus prevented, the surface of the latter is broad and nearly horizontal, as is seen in the annexed view of a

transverse section (*y*) of the joint (*c*), (fig. 40.) The section Y, in the same figure, shows the surfaces of the joint connecting the astragalus with the os calcis, which are parallel to, but broader* than those of section (*y*). These directions of the surfaces of the joints so effectually oppose the lateral movements of the foot inwards or outwards, beyond certain limits, that neither talipes varus,—that is, turning up the inner edge of the foot, nor talipes valgus,—turning up the outer edge of the foot, can take place without a separation, on one side or the other, of one or both these articulations. It must be borne in mind that the sections just described are made vertically through the central transverse plane of the several bones; for the external appearances of the articulations, especially that of the astragalus with the os calcis, are very unlike those represented in fig. 39. In the section of the ankle-joint and foot parallel to the mesial plane of the body, (fig. 39,) the articulating surface of the astragalus presents nearly a circular arc, which allows the foot to rotate backwards and forwards with great freedom in a vertical plane. According to the investigations of the MM. Weber, the angle of greatest flexion between the leg and foot is 78° 2′, the angle of abduction, 20° 5′, and the angle of adduction, 42°; consequently, when either of these angles exceeds this limit, distortion begins. The same section exhibits another circular arc lying between the astra-

* In a specimen before us, the breadth of the one is to that of the other as four to three.

Fig. 39. Fig. 40.

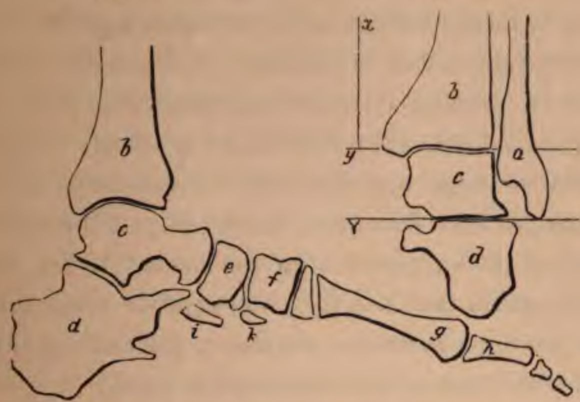


Fig. 39.—A section of the ankle-joint and foot made parallel to the mesial plane of the body; *b*, *c*, *d*, the same as in fig. 40; *e*, the os naviculare; *f*, the second os cuneiforme; *g*, the second metatarsal bone; *h*, the first phalangeal bone; *i*, os cuboides; *k*, the third os cuneiforme.

Fig. 40.—A transverse section of the bones of the ankle-joint and foot; *a*, the external malleolus; *b*, the tibia; *c*, the astragalus; *d*, the os calcis; *x* and *y*, vertical and horizontal lines.

galus and the os calcis, and inclined to the superior arc. The motion of the astragalus in this lower arc is extremely confined, owing to the nature of its articulation with the os calcis; but the advantage arising from the separation of the astragalus from the tibia and os calcis, as well as from the inclination of the arcs just described to each other, is strikingly observable in concussions of the heel, such as occur in walking, leaping, &c. For, of the force impressed vertically during these actions on the lower surface of the heel, a portion only is transmitted, according to the principle of the

resolution of forces, to the astragalus, and of this again, owing to the inclination of the two arcs, a portion only is finally transmitted to the tibia. The foot has also the power of rotating on a vertical axis at the ankle. In this joint the internal malleolus, being short, does not present so large a surface to the astragalus as the external, and the horizontal turning is just the reverse of that of the knee-joint. In the latter* it has been already stated that it is the outer condyle which turns, while the inner is fixed; whereas in the ankle it is the inner which turns, while the outer is fixed.

The surfaces of the joints connecting the navicular bone with the astragalus, and the cuboid with the os calcis, are traversed by the same vertical plane. The former is a ball-and-socket joint, while the latter presents surfaces nearly plane, except a small projection thrown forwards from the os calcis, which locks into a corresponding process of the os cuboides, passing beneath it backwards. It is owing to these two joints that the five anterior tarsal bones have no osseous impediment to that rotation round the projection of the os calcis which occurs in talipes varus; whereas this projection, and the length of the external malleolus, oppose their turning in the opposite direction. The cuneiform bones are so closely wedged together that it is difficult to conceive them capable of being displaced, independently of a corresponding movement of the navicular and cuboid bones. The tarso-metatarsal articu-

* See Motions of the Knee-joint, Chapter VI.

lations are nearly plane surfaces, directed in different planes, some in advance of the others; the metatarsal bones can therefore have but a very slight motion, if any, on the tarsi, which condition is obviously necessary for the preservation of the arch of the foot. The same remarks are not applicable to the phalanges of the toes, which are not necessary to support the arch of the foot, and have consequently considerable mobility, analogous to that of the fingers. The assemblage of bones of which the foot is composed, when in their normal position, presents two longitudinal arches,—the external and internal,—one on each side of the foot. The external arch is formed by the os calcis, the os cuboides, and the fourth and fifth metatarsal bones. The internal arch, which is longer and higher, is formed by the os calcis, the astragalus, the os naviculare, the three ossa cuneiformia, and the first, second, and third metatarsal bones. These two arches have a common origin at the base of the tubercle of the os calcis, and terminate at the tubercles of the metatarsal bones. The cuboid and cuneiform bones are also arranged in an arched form, in the transverse section of the foot, with the convexity above. The longitudinal arches of the foot are preserved from being materially flattened, principally by the calcaneo-cuboid, the calcaneo-scaphoid, and the calcaneo-metatarsal ligaments. The former of these is very strong, and sustains a large portion of the weight of the body; the latter prevents the bones of the tarsus from being separated by the pressure to which they are subjected. These ligaments, acting

like the bowstring on the bow, keep the arches of the foot from spreading; and their elasticity,* together with the number of bones into which the foot is divided, prevents any ill effects from the jars incidental to progression,—an advantage which could not be obtained were the foot composed of a single bone. The flanges of the great internal arch of the foot spring from four points,—namely, the tuberosity of the os calcis, and the tubercles of the first three metatarsal bones; and those of the external arch, from three points,—namely, the tuberosity of the os calcis, (which is common to both arches,) and the tubercles of the two external metatarsal bones. The pressure of half the body is unequally sustained by these six parts of the sole of the foot, when both feet rest on the ground in standing.

* I had long since been of opinion, that the white fibrous tissues, such as the ligaments, are elastic, from a consideration of their structure and office. In order to satisfy myself on this point, I have lately made several experiments on the ligaments of the joints in the lower animals, and found them to possess a very high degree of elasticity, but a very limited amount of extensibility. It was probably the latter circumstance that gave rise to the hypothesis of their being inelastic; but if we admit that the ligaments are, however slightly, extensible, it follows that they must also be *elastic;* for otherwise, the application of every force sufficient to stretch them would leave them elongated; and by continued elongation, the whole of the joints in the skeleton would in the course of time become loosened, and finally dislocated, which is contrary to experience. I believe this to be the first time that this property of the ligaments has been noticed, for in the latest physiological works they are stated to be inelastic.

Fig. 41.

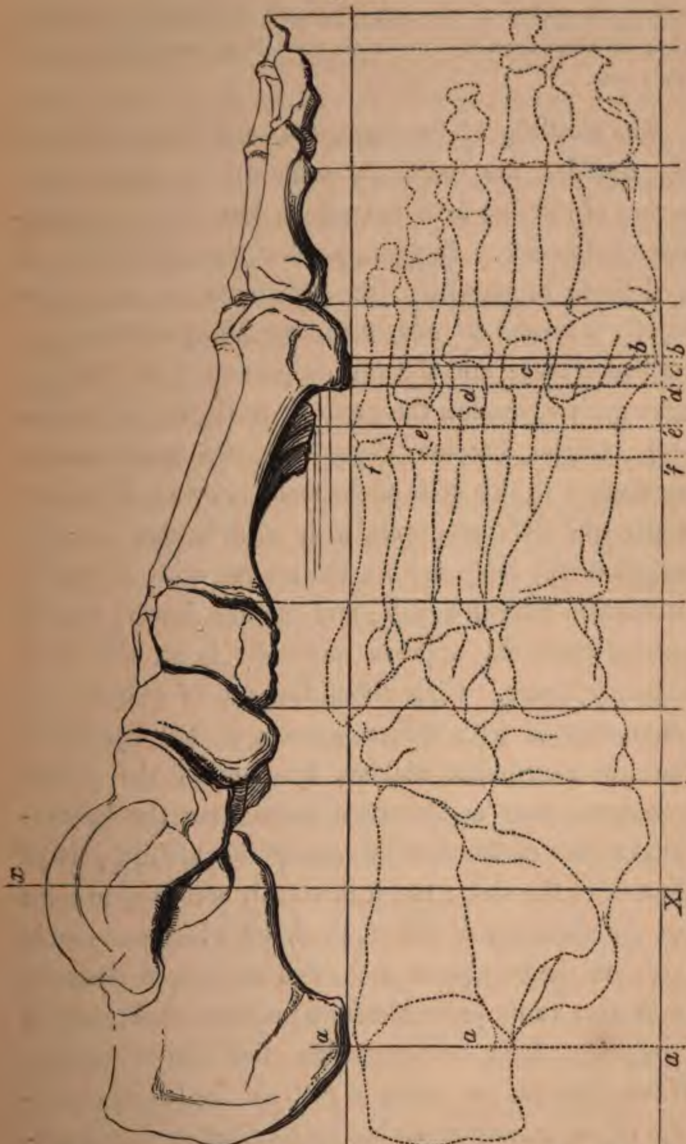


FIG. 41—Represents a side view of the bones of the foot, with a figure of its under surface inverted, to show the relative posi-

tions of corresponding parts; a, b, c, d, e, f, are the six parts in which the arches of the foot terminate, and a', b', c', d', e', f', their distances from the line x, X, in which the weight of the body acts.

The elasticity of the ligaments, and the tonicity of the muscles, are ordinarily sufficient to preserve the arches of the foot from flattening; but there are exceptions to the rule. In some persons, especially those of a delicate organization, the ligaments are not sufficiently powerful to prevent the spreading of the longitudinal arches; and the central portion of the feet, in consequence, reaches the ground, while the ligaments and muscles become elongated, and accommodate themselves to this state of the foot. Persons labouring under such deformity walk with an awkward gait; the weight of the body reaches the ground with a greater concussion than in health; and the foot, having lost its natural convexity, appears unusually large, and of an ungainly figure. Girls about the age of puberty are often affected with this relaxation of the ligaments. Surgical instrument makers, ignorant of the proper treatment, have endeavoured to preserve the longitudinal arches of the foot by raising the middle part of the sole of the shoe; but it is scarcely necessary to point out the absurdity of this method, by which pressure is made on the only parts of the foot which were designed by Nature to be protected from pressure, and produces mischief without accomplishing the object sought. When attempts are made to restrain the lateral expansion of the transverse arches by contracting the dimensions of boots and shoes, the corns and bunions thus

produced sufficiently show, without any lengthened reasoning on the subject, that such a remedy is utterly inadmissible. Under ordinary circumstances, the foot cannot turn much beyond the limits already assigned, without stretching some of its ligaments. If the latter are in a healthy condition, great force is necessary to stretch them even to a very small extent, and when that force is withdrawn, they quickly return to their original length; but they will rupture rather than yield to a considerable stretching force, especially if it be suddenly applied. When, on the contrary, the ligaments are weak, and possess a low degree of elasticity, the foot may be easily distorted in almost any direction in which it is susceptible of moving; and although the ankle partakes so largely of the nature of a hinge-joint, it is not rigidly so, like the elbow-joint, and is therefore capable of the movements already described.

MUSCLES.

The muscular force employed to keep the limbs in a state of equilibrium is under the control of the nervous system; and it has been already demonstrated in Chap. III. that this equilibrium is in no wise dependent on the equality of power residing in the muscles which oppose each other's action, but that, on the contrary, the power of the extensor muscles in general greatly predominates over that of the flexors. This principle applies to the muscles of the foot,* and it may there-

* I do not here intend to follow Rudolphi, Walther, and others, who class the gastrocnemii with the flexors of the foot, whatever may be their analogy to the flexors of the hand.

fore be easily imagined, that when their equilibrium is disturbed, the action of the strongest will generally preponderate, and that distortion of the limb will follow. This, however, is not always the case. The extensors may happen to be the muscles paralyzed, and then the limb is distorted in the opposite direction. Now, although the muscles are not the primary causes of distortion of the foot, most pathologists agree that they are at least the agents employed in the production of many of its forms. In consequence of the commonly received opinion, that the elongation of one set of muscles, and the contraction of another, are the obstacles to be overcome in the treatment of such distortion, sections of these muscles have been extensively employed by surgeons in England, France, and Germany; and it is contended that this is the most efficacious and proper treatment to restore muscles, which are either too long or too short, to their natural length. Such being the practice, it is manifestly of the greatest importance to ascertain precisely the normal functions of the muscles selected for the operation; since otherwise muscles may be mutilated to no purpose, as has often been the case in these and similar functional maladies. I shall select one or two instances to illustrate the necessity of exercising this caution.

There are perhaps no muscles in the human body that have suffered to so great an extent from operative surgery in distortions of the feet as those which terminate in the tendo-Achillis; let us therefore first examine the real influence of these muscles on the movements of the foot. If a vertical section of the

ankle-joint is made through the centre of the astragalus, parallel to the mesial plane of the body, the plane of the section will lie on the inside of the heel, as in x, fig. 42. When, therefore, the tendo-Achillis

Fig. 42.

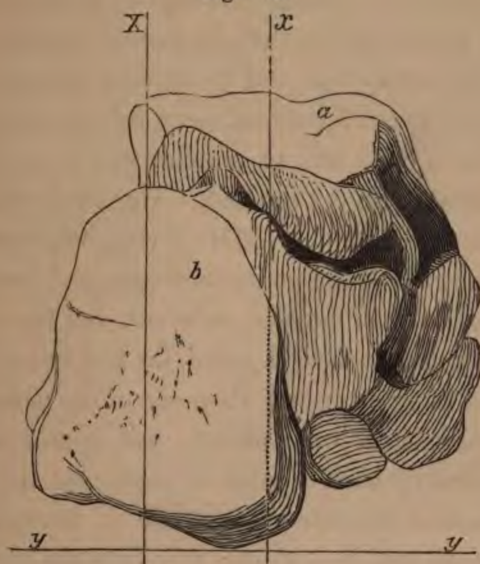


FIG. 42.—A posterior view of the left os calcis and the astragalus, showing the action of the gastrocnemii muscles; *a*, the astragalus; *b*, the os calcis; *x*, the axis of the horizontal movement of the foot; *X*, the direction of the force of the tendo-Achillis.

raises the heel in the direction of X, it must also tend to raise the outer edge of the foot, with a leverage whose length is the distance between X and x; and when the gastrocnemii muscles are spasmodically contracted, or their opponent muscles paralyzed, they may

be instrumental with the aid of the peronei, in producing valgus, or equino-valgus.*

Hence it is obvious that if in talipes varus the tendo-Achillis is cut, it must increase the mischief; for one of the counteracting forces to the muscles which really produce the distortion is thereby rendered powerless. It is well known that the peronei muscles tend to raise the outer edge, and the tibiales the inner edge, of the foot; and if these tendencies balance each other, the action of both sets of muscles will be confined to extending and turning the foot. This has been verified by the experiments of the MM. Weber, who found that when the heads of the peroneus longus and brevis, and the posterior tibial muscles, were cut, and the muscles themselves simultaneously pulled, the foot was extended. The same thing happened when one of the peronei and the posterior tibial were pulled; but neither of these muscles was by itself capable of producing this effect. Surgeons who advocate the practice of tenotomy will therefore do well to consider very carefully the consequences of suspending, even for a time, the action of parts, which, if improperly neutralized, may perhaps

* In the distorted foot of an anencephalous fœtus of seven months, Tourtual found that the navicular and cuboid bones were rotated on their axes, and that the astragalus was partially displaced, the posterior articulating surface being in contact with the tibia, owing to the extended position of the foot: the os scaphoides touched the internal malleolus, and the posterior tuberosity of the os calcis was drawn towards the fibula outwards and upwards.

render incurable a disease that might otherwise have been subdued.

THEORY OF THE ORIGIN OF CLUB-FOOT.

A great diversity of opinion has existed, from the time of Hippocrates to the present, respecting the origin of the various forms of club-foot. An excellent summary of these opinions will be found in Dr. Little's treatise on the subject. A minute examination of the various hypotheses already promulgated would lead to a very lengthened inquiry, attended with little advantage. It will, however, be desirable to take a glance at some of the more important of these views, in order to appreciate the present state of our knowledge in this branch of surgery. We will, in the first place, turn our attention to the opinions respecting the origin of congenital club-foot. Many children exhibit at their birth some kind of distortion of the foot, consisting either in a malformation or a malposition of its bones, associated with abnormal contractions of some of the muscles. In this part of the subject we at once encounter difficulties of no ordinary nature. The infant is deformed during its development in the uterus. What, then, is the cause of this deformity? Cruveilhier and others think that the malady is owing to malposition of the limbs of the fœtus, in relation to each other and to the body, by which their mutual development is impeded,—thus ascribing to it a mechanical origin. Stromeyer is of opinion that, if contraction of the gastrocnemii muscles takes place in the earlier periods of utero-gestation, and

before the development of the internal malleolus and the ligaments connected with it, talipes varus results; but that, if the contraction of these muscles takes place after the malleolus and ligaments of the ankle-joint are perfectly formed, talipes equinus, either with or without a slight inward inclination of the foot, is presented at the birth. Glisson and Camper attributed this deformity to distortion of the astragalus; Naumberg and Wenzel, to its malformation or malposition; Blumenbach, to the shortness of its neck. Dr. Little concurs in the conclusions of Scarpa, that of all the bones of the tarsus the astragalus is the least liable to distortion, and that this fact alone is sufficient to prove the possibility of curing infantile talipes varus. He is also confirmed in the opinion, partly derived from the views of Rudolphi, Jörg, and Stromeyer, and partly from his own investigation into the symptoms and morbid anatomy of the disease, "that club-foot, whether occurring in the fœtal state, or subsequently, is merely a distortion of parts originally well formed." Rudolphi appears to have taken a rational and scientific view of the origin of congenital talipes. He supposes the malady to arise during the fœtal state from some disorder of the nerves supplying the distorted limb. The experiments of M. Bonnet show that the tibial nerve is the motor of the flexor and adductor muscles, and the nerve of sensation of the plantar side of the foot; and the peroneal nerve the motor of the extensors of the toes and abductors of the foot, and the nerve of sensation on the dorsal side. A diminution or loss of power in

either of these nerves produces deformity, owing to the preponderance of the action of the muscles which antagonise those supplied by the affected nerve. The section of the tibial nerve accordingly produces valgus, and the section of the peroneal nerve, pes equinus and varus, as well as equino-varus. Hence it follows that prolonged irritation or spasm of one of these nerves produces a corresponding deformity. Wolff and others are likewise of opinion that nervous affections are the fundamental cause of these distortions; cramp producing one kind of deformity, paralysis the opposite. This hypothesis may be entitled to further consideration at a future time, but it is not necessary to examine it more minutely at present. Non-congenital club-foot often arises shortly after birth, and at various subsequent ages. Numerous causes tend to disturb the nervous system in infancy and the subsequent stages of development. During the period of teething, cramps of the limbs and general convulsions are common, arising from irritation, either in the gums or the intestinal canal, &c., and acting through the reflex system of the spinal nerves. These effects are sometimes permanent, remaining after the cause of irritation is removed: in such cases there is probably some change produced in the central portion of the nervous system, which causes the contracted state of the muscles of the limbs, and which the power of volition cannot afterwards control. Infantile club-foot may exhibit the same malposition of parts which occurs in the fœtal state, and there is no distinguishing mark to determine whether the disease is of congenital or non-congenital origin.

When cases of varus and valgus are neglected, and the patient is permitted to walk for a length of time on either edge of the foot, the tarsal bones become distorted, and the case is irremediable. Dr. Colles relates two cases at the ages of five and eighteen, in which these bones had become distorted by walking with the foot in the position of varus. Other cases are mentioned by Jörg, in persons aged thirteen and sixty; in the latter of which there was twisting of the tibia and malformation of the astragalus, and the articulation of the ankle was transformed from a ginglymoid to a ball-and-socket joint. Thus, in the early stage of club-foot, we have to deal, in many cases, with malformation of the tarsal bones, and an abnormal contraction of muscles; but in cases of long standing we may have malposition complicated with malformation. In confirmation of this statement, there are, in addition to the researches of the authors already mentioned who have written on the morbid anatomy of club-foot, many preparations in the various museums of Europe. In illustration of abnormal contraction of the muscles produced by mechanical causes, may be cited that of the gastrocnemii, resulting from an unequal length of the legs. In cases of this kind, which are not unfrequent, persons generally resort to walking on the toes of the shorter foot, in order to make up the deficiency. After having used the foot in this manner for a considerable time, its extensors become contracted, and the heel cannot be brought to the ground; thus giving rise to talipes equinus, and, if the contraction be great, to equino-valgus. Some of the cases of talipes equinus related by

Dr. Little appear to have thus originated. He observes —"The legs are often shorter, in proportion to the stature of the individual, and the feet usually smaller. I have sometimes found, when one limb only is affected, the difference in the length of the extremities amounted to as much as four inches." These are precisely the cases in which pes equinus results from those spontaneous adjustments which, according to the laws of dynamics, are necessarily produced, in order to compensate for the deficiency in the length of the leg. Such being the origin of these cases, it is easy to deduce the nature of the appropriate treatment. If the persons threatened with this deformity were not suffered to walk on their toes to make up for the deficient length

Fig. 43.

Talipes equinus.

of the leg, no contraction of the muscles would take place. But, if contraction has already occurred, what would happen on the division of the connected tendon? The foot extended in the position (fig. 43), is capable of being flexed after the division of the tendo-Achillis,—a position which enables the sole to assume a horizontal direction; but when this is done, the foot cannot reach the ground; the leg, therefore, again becomes too short, and a high-soled shoe, or some similar expedient, must be used, to make up for the deficiency of length. The section of the tendon does not remove the cause, but merely one of the effects of the complaint. These cases should not, however, be allowed to exist; for if patients were supplied from the first with proper means of walking, this distortion would never take place.

In some persons, the rotation of the foot on the ankle-joint horizontally inwards is augmented by the rotation of the whole leg in the same direction; and it is not uncommon to see individuals walking in the streets with the toes of both feet pointing towards each other,—that is, directed perpendicularly to the mesial plane of the body. These cases sometimes begin in varus, and end in a rotatory movement of the feet through an arc of ninety degrees. A case of this kind, in a boy aged three years, is now under the author's care. The feet, when lifted from the ground, are in the position of talipes varus, the os naviculare being at the same time drawn towards the internal malleolus; but when the soles rest on the ground, the feet rotate

inwards, owing to the contraction of the tibialis posticus, so as to be at right angles with the mesial plane. When the feet are put into their normal position, which is easily effected by a slight pressure of the hand (although they relapse into varus as soon as the hand is removed), the muscles concerned in producing this deformity are slightly extended, but they do not act strongly or present any material obstacle to the retention of the feet in their normal position by the ordinary mechanical treatment.

CHAPTER VIII.

MECHANICAL AND OTHER CAUSES OF DISTORTION.

Distortions of the foot (continued). — Talipes calcaneus.—Tenotomy.—Calcaneo-metatarsal ligament not instrumental in the production of talipes.—Congenital malformation of tarsal bones.—Its treatment only palliative.—Alterations in the form of the tarsal bones produced by mechanical causes.—Case illustrating this form of distortion.—The hand liable to distortion.—Various positions which it may assume.—Theory of abnormal contraction of muscles.—Power of elongation in the antagonists of contracted muscles illustrated.

Besides the several forms of talipes described in Chap. VII., in which the foot, being preternaturally extended, abducted, or adducted, gives rise to talipes equinus, talipes equino-varus, and talipes equino-valgus, there is another form which is more rare, less permanent, and attended with less injurious effects—namely, talipes calcaneus, in which, when the body is upright, the heel only rests on the ground. In this condition of the limb, the action of the flexor muscles of the foot preponderates over that of the extensors, which is contrary to the tendency of the action of muscles in general. This form of distortion is often congenital, but may arise at any period of life, if the motor nerves of the flexor muscles are in a state of exalted action. In the earliest stages of infantile existence, when the spine is

unable to support the head and trunk, the body falls backwards and forwards, unless it is supported. Infants are often suffered by parents and nurses to remain with the trunk in a flexed position, by which means the spinal cord is bent, and the anterior column more or less compressed, and forced into a curve corresponding to the flexion of the body. Under these circumstances, in conjunction with various other causes which operate on the nervous system of infants, it is not surprising that the foot sometimes takes the form here mentioned. This may happen either in one or both limbs; but, as the foot can be extended with very little force, and the powerful extensor muscles are ready to aid any mechanical means that may be employed to correct the distortion, while the weight of the body tends to bring the foot into its natural position as soon as the patient is old enough to walk, little difficulty is experienced in restoring the foot, by very simple methods, to its natural state. Mr. Tamplin, however, considers the section of numerous tendons necessary in these cases, and gives the following directions :—

"The plan I have adopted is the following:—to pass in a small sharp-pointed knife on the inner side of the extensor communis, beneath the tendons of that muscle, and also that of the peroneus tertius, and to divide them; then to introduce the knife on the outside of the anterior tibial and extensor pollicis tendons (which you will find raised from the joint), pass it inwardly (as it regards the leg) beneath them, turn the sharp edge of the knife to the tendons, and divide

them; you will then avoid the risk of puncturing the anterior tibial artery, which, *although it might be compressed easily, had better be avoided*."*

This passage affords a fair illustration of the general practice of those who believe that the section of tendons is the proper treatment in these cases of infantile distortion of the foot. But, after what has been already stated in Chap. III., relating to the subject of myotomy and tenotomy, it will be unnecessary to express any opinion on the treatment recommended by Mr. Tamplin in these particular cases.

Maisonneuve and others consider that the calcaneo-metatarsal ligament, or aponeurosis plantaris, is instrumental in the production of talipes varus. Delpech, on the contrary, rejects this hypothesis, because it is insufficient to explain the occurrence of talipes valgus; but it appears to the author that both the hypothesis and the objection are equally groundless, since a close examination into the relative positions of the several points of attachment of the ligament in question will be sufficient to convince any person, having even a slight notion of mechanics, that its contraction cannot possibly produce abduction or adduction of the foot, much less varus or valgus. The office of this ligament (as stated at page 121) is to preserve the longitudinal arches of the foot, and its attachments are arranged accordingly. It may here be observed that the functions of the ligaments have not been sufficiently studied,

* Tamplin's Lectures on Deformity, p. 89, 90.

and that little is known of their pathology. Their extensibility and contractility under ordinary circumstances are confined within very narrow limits; but these properties vary in different persons. Some persons have very little mobility in the joints of the spine and extremities. Others, used to gymnastic exercises, can bend the trunk backwards, and touch the ground with the back of the head, showing a great degree of extensibility, and a diminished force of elasticity in the perpendicular and crucial ligaments of the spine.

When distortions of the foot arise from congenital malformations of the bones, it is obvious that the treatment, although it may often be of great service, can only be palliative. Long-continued use of the feet in certain positions will, moreover, so materially alter the figure of tarsal bones originally well formed, as to render the case equally intractable with those of congenital malformation. The following case will serve as an example:—

The patient, a gentleman, aged fifty years, living in the country, states that he had enjoyed perfect health until he was six years old, but that in November 1803, after frequently sitting on the ground, he was seized with a fever, which for a time seriously affected the brain, and was attended with cutting pains in the calf of the left leg, which from that time began to lose a portion of its volume. When the febrile symptoms had subsided, he had recourse to the warm baths at Bath, which were continued for six months. He then began to tread on the external edge of the foot, and

had recourse to iron supports. The temperature of the deformed leg is much lower than that of the other, and he suffers much in it from cold and chilblains during winter. Since the first attack he has suffered once from rheumatic fever, owing to lying in a damp bed; and was confined a short time from an injury of the spine, produced by the seat of a mail-coach, which has left a chronic pain in the back. On examination, I found that the astragalus had rotated with the os calcis laterally inwards; the cuboid and internal cuneiform bones nearly approximated, and the five anterior tarsal, the metatarsal, and phalangeal bones, had rotated through an arc of 156°, so that the plantar side of the foot turns upwards, as seen in fig. 44, and the patient walks on the dorsum of the foot.

Fig. 44.

The compression on the side of the transverse arch, produced by the weight of the body, has made a longitudinal furrow in the sole of the foot (fig. 45). As the foot, in its present state, is ill adapted to sustain the weight of the body, and the friction incidental

Fig. 45.

to walking on its dorsal surface, the skin formerly became abraded, and the patient walked with pain and difficulty. To remedy this evil, he contrived a boot, which suited the altered form of the foot, and being wadded, protected the skin from injury; by which means he can walk as many as twenty miles in a day. The deformity has existed from the period of his sixth year, and the exercise of the foot in the position already described, during so many years, has produced such an alteration in the articulating surfaces, and in the figure of the tarsal and metatarsal bones, that there is no longer any prospect of restoring the part to its normal state, either by mechanical or surgical treatment. The patient is willing to submit to the amputation of the limb; but as he is capable of walking many miles with the limb in its present state, and merely presents a limping gait in walking, I advised him to continue the use of it; and he ultimately agreed with me that an imperfect natural limb

is better than a wooden one. This is one of the cases continually presented to the surgeon, wherein remedial measures have been neglected in the early stages of the complaint, when success is scarcely doubtful; and which in the course of time become of so intractable a character, as to render a cure impossible. It appears that during the fever the patient had been delirious for about a fortnight, and at the same time had lost the use of both legs, one of which only recovered. Hence there can be little doubt that, under the attack of fever, the spinal cord suffered some permanent organic lesion. In fact, the majority of cases of talipes proceed from causes which, as far as observation extends, are not of a purely dynamical nature; but, as is stated in page 129, are referable to some disordered condition of the excito-motor portions of the nervous system.

When these disorders arise early in life, the muscles affected, not being fully developed, are easily brought into a normal position; but when remedial measures have been long neglected, the muscles not only offer greater resistance, but, according to the principles already detailed in Chap. III., become contracted. When, for instance, muscles, such as those which raise the heel in walking, and which are instrumental in the production of talipes equinus, are affected in the adult, it may readily be imagined that, owing to the size of these muscles, considerable force would be necessary to stretch them; but it must be remembered that in this case the weight of the body would act at a

mechanical advantage in depressing the heel, while the muscles would not be opposing the depression with their normal power. When the tendo-Achillis is divided, the distorted limb requires to be kept in the proper position for a considerable time. The author has been called in to complete the cure of cases of tenotomy, which, although the subjects were young persons, required the use of instruments many months after the division of the tendon. This circumstance furnishes an additional argument against tenotomy in general, since in many cases the cure is not hastened by that mode of treatment.

The superior extremities are much less subject to distortion than the inferior, the latter having a far greater amount of labour to perform, in the daily exercise of supporting and propelling the body. The joints of the superior extremity are in like manner less subject to disease than those of the inferior, and paralysis and spasm of the muscles are less frequent, while the distortions which do occur are often the result of mechanical violence. Fractures of the clavicle, acromion, coracoid process, and neck of the scapula, when neglected or improperly treated, leave the positions of the two shoulder-joints unsymmetrical, and attended with an impaired range of movement in the arm. Although the shoulder and hip are joints of analogous structure, the former usually escapes those serious affections which so commonly happen to the latter. The analogy between the structures of the elbow and knee joints is not so close, yet the proportion of their morbid states

is perhaps nearly the same with that existing between the shoulder and hip joints. The simplicity of the structure of the elbow, compared with the knee, is among the causes tending to preserve the former from disease; but if we take into account the cases of distortion resulting from mechanical violence, the elbow is, of the two, much the more subject to derangement. When persons fall from a great height, they rarely reach the ground on their feet. In the act of falling the body is usually inclined to the horizon, and the impulse given to it at the moment of departure generally causes it to rotate more or less on its long axis, about the centre of gravity, and thus the head and superior extremities often reach the ground before the feet, and as the arms are naturally extended to break the force of the fall, fractures, dislocations, and concussions, terminating in contractions of the limbs, with diminished range of motion, often result. It is, indeed, very surprising how many of those who fall from great heights escape instant death, or at least the most serious consequences. The nature of the ground on which the body falls produces very great differences in the effects. Thus one person may fall from the top of a cliff eighty feet in height, but, in consequence of pitching upon the loose gravel of the beach, escape with a few trifling bruises; whilst another, in walking along the pavement of London, accidentally slips, falls backward, strikes the occiput against the edge of the curb-stone, and fractures the skull. The latter case is familiar, and an instance of the former happened not

long since, at Ramsgate. The following occurred among many similar cases in the author's practice. A painter, standing on a ladder, fell to the ground from the height of forty-five feet, pitched on some soft earth in a garden, and escaped with only a fracture of the coracoid process of the scapula. When it is borne in mind that the force with which the body reaches the ground is as its weight multiplied by the velocity acquired during its descent, it is astonishing that any such accidents should not end fatally; but these occurrences show how beautifully the mechanism of the body is adjusted to resist the severe shocks to which it is liable. There will be found, in Sir Astley Cooper's Treatise on Fractures and Dislocations, many examples wherein external violence has injured the mechanism of the joints, and distorted the positions of the limbs; and the nature and treatment of diseases of the joints have been so fully considered by Sir Benjamin Brodie, M. Bonnet, and others, that it is needless to enter here into any detailed account of these branches of the subject.

Anchylosis of the joints of the superior extremities is not so prejudicial in distorting other portions of the body as when it occurs in the legs. The loss of power to swing the arm, owing to an anchylosed state of the shoulder-joint, tends to occasion twist of the trunk; but fortunately these cases are of rare occurrence. Anchylosis of the elbow-joint would not have the same tendency to alter the figure of the trunk. The fore-arm and hand may be fixed in a state of pronation or

supination, either from an altered state of the joints, or from contraction of the muscles. The structure of the wrist allows it a greater freedom of motion than the tarsus, the bones being smaller and weaker, and endowed with a greater degree of mobility, so as to enable the hand to perform its various movements. By means of injections, M. Bonnet has shown the various positions which the hand may assume in cases of effusion within the joints. He states that the frequent participation of the second row of the carpal bones in the diseases of the first is owing to the prolongation of the synovial membrane from the first to the second. The hand is liable to distortions of the same nature as the foot;—that is, under those pathological conditions of the nervous system which, by producing spasm and paralysis, disturb the equilibrium of the muscular forces. The hand may be retained in a state either of transient or permanent flexion, extension, abduction, pronation, or supination, according to the class of muscles involved in the malady. In the majority of cases, the influence of the principle already mentioned is observed; namely, that the greater amount of action takes place in the most powerful muscles, rather than in the weaker; only in the hand the flexors are more powerful than the extensors, an exception to the rule observed in other parts of the body. When the extensor muscles are paralysed, their antagonists draw the hand into a state of permanent flexion; for these muscles, having lost their normal tension, become permanently contracted, and

the limb, not being exercised, becomes more or less atrophied, as may be observed in many cases of club-hand.

Pathologists do not appear to have observed with much attention the changes which muscles undergo when released from the tension and action to which they are subjected in their normal state. Abnormal contraction, as well as elongation, takes place slowly and gradually through minute spaces. If a limb, such as the arm, is kept bent during twenty-four hours, there is a sense of distress when it is again extended; but, if the period of its being retained in a bent position is prolonged to some weeks, the limb cannot at once be perfectly extended. Or let us suppose the period of continued relaxation of the extensor muscles of the leg to be six weeks, and the consequent contraction during that time to be an inch, which agrees with an observed case in an adult, then, since the contraction is gradual, if we also suppose it uniform, 1-40th of an inch will be the contraction each day, and the muscles will require time to recover their normal length, resisting any sudden elongation with an energy proportional to their masses. Since, then, the law of elongation is similar to that of contraction, we see why persons who attempt suddenly to elongate a muscle must fail, although the desired effect may be easily accomplished by promoting the gradual restoration of muscles to their normal length. A man who had fractured the patella of the right knee, stated that, in the treatment of this injury, both legs had been kept

in an extended position for several weeks; that when he was released from this position, the range of motion of the sound leg was much reduced, and that it was some time before he could flex that leg at right angles with the thigh. The right leg had lost the power of rotation beyond about 45°, an effect which most probably depended, partly on distortion of the patella, and partly on contraction of the extensor muscles, and not on any elongation of the flexors; for on that supposition the limb might have been fully bent by the aid of the hands, which in this case was impracticable. The unsound leg was unable to support the weight of the body steadily, so that he had recourse to the use of crutches for a long time. The gradual restoration of the sound leg to a normal range of motion, by mere exercise of the limb, proves beyond dispute the possibility of muscles becoming elongated simply by the action of their antagonists, whenever the nature of the case admits of the adoption of this principle. This is, however, a subject which will occupy particular attention subsequently.

CHAPTER IX.

PATHOLOGY AND MORBID ANATOMY OF DEFORMITIES.

Conditions of the body in caries, rickets, mollities ossium, and difficulty of obtaining the natural history of these diseases.—Difficult problems presented in the study of these cases.—No theorem furnished to solve the questions presented.—Movements of the vertebræ consequent on the absorption of their bodies; parts of vertebræ attacked.—Hypotheses of Ambrose Paré and Dr. Harrison refuted.—Constitutional symptoms.—Effects on the spinal cord.—Hypothesis of luxation of vertebræ untenable.—The proposition, that prominence of the spinous processes is not owing to their being driven backwards, demonstrated.—Figure of the spine due to the form of the bones.—Intervertebral cartilages sometimes hypertrophied—sometimes absorbed.—Spongy structure of bone most liable to be affected with caries.—Cases of caries.—Hypothesis of dyscrasy of the blood.—Views of Pott, of Sir B. Brodie, and of Dupuytren.

THE pathology of the body under the various conditions which terminate in caries, rickets, mollities ossium, &c., deserves the most careful and unwearied attention, not only on account of their aggravated nature and injurious effects, but also on account of their general prevalence. Their duration is modified by various circumstances. When caries is associated with syphilis or scrofula, the period of time over which it extends is greatly augmented; in syphilitic patients,

frequently terminating only by the death of the victim; but in those cases which are not aggravated by a specific cause, and which occur in young persons, the duration of the malady is more defined, and extends over a shorter period, varying from three to about seven years. It very rarely happens that these cases are left entirely to nature; and since we do not know precisely how far the remedies employed may have affected their character and duration, it is impossible to give a strictly natural history of the disease; still an approximation may be made to such a history, because, in spite of all the means hitherto devised, the disease will frequently run its course through certain stages, present certain characteristic phenomena, and terminate in certain organic changes, leaving permanent and lamentable traces of its effects. Notwithstanding this melancholy truth, it is a disorder in which much might be done both to weaken the intensity of the exciting causes, and to diminish their effect.

The study of the derangements of the vital functions, coincident with the earliest appearance of the symptoms common to them all, is the first and most important step towards obtaining a correct and general knowledge of the pathology of the disorders. After this, the symptoms peculiar to the various forms and stages of the different diseases require to be most closely observed, and rigidly discriminated. In reference to the whole of the perturbations of the vital and animal functions which come under our observation, it is necessary to make a clear distinction between

causes and effects. The nature of many of the pathological changes being beyond the reach of our observation, we are obliged, from the alterations of structure discovered by means of morbid anatomy, to infer what were the pathological conditions that preceded the death of the individual. But here we are met by another difficulty. In most cases, the patient either wholly recovers, or at any rate survives the active stage of the disorder; and thus a long series of changes may intervene before the opportunity of an examination occurs, and hence the determination of the actual derangement of the system during the progress of the complaint is rendered much more uncertain. We have in these cases to deal with disordered functions in parts of the system where the mechanism cannot be inspected, and in which the laws of the functions themselves are undetermined. In fact, this problem is one of much greater complexity than that inverse problem of the planetary perturbations which has been recently solved by Mr. Adams and M. Le Verrier, and which has terminated in the discovery of a new planet. We have no observations analogous to those furnished by Flamstead, Picard, and Bouvard, and no law like that of gravitation on which to found our investigations. The perturbations of the functions of the animal system are much more difficult of solution than those simply relating to the motion of bodies, because they are influenced by dynamical and chemical forces that are themselves controlled by an agency the nature of which is yet a mystery.

It may be said that we have no men in the medical profession of the same powerful intellect as those who have brought the exact sciences to such a pitch of perfection. But have we not had Dr. Thomas Young?—have we not had Cuvier?—have we not had John Hunter? Of these, the first was a man of the most distinguished talent, and possessed so profound a mathematical knowledge of the physical sciences as would have rendered him competent to resolve problems such as those under consideration, had the necessary data for this purpose been furnished; but to his philosophic mind the art of medicine appeared a complete chaos, and the only physiological question he attempted to investigate was abandoned by him, as he himself has stated, through despair of bringing the subject to a satisfactory conclusion. Cuvier and Hunter spent the principal part of their lives in describing the mechanism by which the animal functions are performed, but could not proceed farther. They could neither detect the nature of the forces by which the machinery is moved, nor the laws of its motion; their labours were limited by these boundaries, and all their attempts to proceed farther than the classification of animals according to their organization, completely failed. It is well known that Matteucci and others have made experiments with a view to determine the kind of force associated with nervous matter when in action; and, considering what has been already accomplished, it is not impossible that similar experiments may lead to successful results. After what has been

said, it will not be expected that a general theorem should be furnished, whereby all questions relating to the physical changes going on in the living body may be solved, as has been done with respect to all those changes which affect merely the various movements and attitudes of the body, both normal and abnormal.

Experiments have shown that the old particles of the bones, like those of all other parts of the body, are carried away in the vortex of the circulation, and are replaced by new particles, similar in their nature, composition, and structure, to their predecessors. Where there is so much activity in the movement of the particles, and while the mechanism is so complex, it is easy to conceive, without knowing the nature of the forces employed, that so large a number of organs concurring to one end must be as liable to derangement, either primarily or secondarily, in the osseous system, as in the other structures of the body. Spontaneous caries of the vertebræ does not present itself simply as a local affection, there evidently being a peculiar condition of the system under which the disease is induced. Before any local symptoms sufficiently marked to fix the attention arise, the general system betrays that something is wrong. / Patients predisposed to this affection show symptoms of constitutional derangement, usually at some period between the limits of infancy and puberty. They are observed to become gradually weak and languid, with the mind depressed, and temper fretful, and to suffer fatigue merely from the act of standing, accompanied by a desire to rest the

body against any adjacent object for support; the appetite is deficient, corresponding to the atonic state of the digestive organs; the normal balance of the assimilating, absorbing, and secreting processes is disturbed, as may be inferred from the pallid countenance and anæmic state of the body; the pulse is usually feeble and quickened; the skin subject to periodical perspirations, which are usually nocturnal; the urine contains phosphatic earths, which the assimilating organs do not replace in the diseased bone. When these perturbed conditions of the system have continued a short time, pain is felt in some portion of the vertebral column, which is increased on alternately extending and flexing the body. The locality of the injury may now be detected, either by pressure with the finger causing increased pain, or by gentle percussion; the latter being the most efficacious method, owing to the transmission of the impulse from the spinous processes of the body of the bone, which is commonly the seat of the mischief. If any absorption of the bodies of the vertebræ has taken place tending to diminish their height, the spinous processes of the diseased and adjacent vertebræ will appear, on viewing the back laterally, to project slightly backwards, either within or without the mesial plane, and the number of the projecting processes will in some measure indicate the number of diseased vertebræ, deducting at least two, for the vertebræ immediately above and below. In the first stages of the disease, the projections of the spinous processes are only just perceptible. As the

absorption of the osseous matter proceeds, they increase, and the trunk falls forwards—the amount of the distortion depending on the number of vertebræ affected, and the quantity of matter lost. As the malady progresses, the pain in the back increases, and the nervous system becomes more disturbed. When the absorption is completed, the bodies of the vertebræ above and below come in contact, and afford to each other a fulcrum which resists further distortion, and gives support to the head and trunk. In subsequent stages, the intervertebral cartilages and ligaments of the part affected become diseased and absorbed, leaving the sheath, at the anterior column of the spinal cord, exposed. If any of the vertebræ happen to press permanently on the cord, paralysis of the lower extremities results; if the pressure is produced only in particular attitudes, spasmodic contraction of the muscles of these extremities supervenes, very commonly in the adductors, by which the legs are thrown across each other, and remain in this posture until the pressure is removed by changing the attitude of the body.

Sometimes the bodies of the vertebræ are attacked with caries only at their anterior surfaces, as seen in Fig. 46, and in these cases the spinous processes do not project; so that, provided the disorder has not penetrated to a great depth beyond the anterior surface of the bone, no external malformation is produced. But the effects are very different when absorption begins at the superior and inferior surfaces, in which case the spinous processes of the diseased bones soon become

Fig. 46.

...g. 46.—From the *Museum of St. George's Hospital,* num-
...28. Caries of the vertebræ, natural size. Description

in Catalogue. Three last dorsal and two first lumbar vertebræ; the anterior part of the last dorsal and first lumbar has been destroyed by caries; bony anchylosis has taken place between these vertebræ on the right side, but there is little deformity.

prominent by the changes in the positions of the adjacent vertebræ, above and below. Dr. Harrison has however stated that, when the bodies of the vertebræ become absorbed, the spinal column, though unsupported where the vertebræ are wanting, is generally preserved nearly erect by the resistance it meets with from the contiguous viscera; but this opinion is so completely at variance with experience, and also with our knowledge of the mechanical functions of the bodies of the vertebræ, that it is perfectly unnecessary to offer any further remarks on the subject. Another untenable view taken by Harrison, and also by Ambrose Paré, is that, when the spinous processes of one or more vertebræ become prominent, the cause of the projection is the incomplete *luxation* of the vertebræ; and Harrison states, that *sub-luxation* often produces pressure on the spinal cord, or some of the spinal nerves at their origin, followed by an endless train of complicated nervous symptoms. The explanation given of the mode in which the sub-luxation of the vertebræ is supposed to take place is as follows:—"The muscles destined to move the spine are attached to the articulating fibrous structure, and not to the vertebræ which it encloses: this substance is stretched by them, and in weakly habits becomes preternaturally elon-

gated, partly by the muscular force *pulling* it, and partly by the bones being *pushed* against it in the various turns and gesticulations of the body. As these parts gradually give way, the joints slowly enlarge and admit of greater motion. A slight luxation is first produced in one joint, and afterwards in several." It will merely be necessary to refer the reader to Chapter II. for sufficient data to refute these opinions respecting the derangement of the mechanism of the spine; and, but for the reputation and extensive practice of Dr. Harrison, and the extraordinary treatment which was founded on these opinions, they would not have been cited in this work. In order, however, to prove beyond dispute that the prominence of the spinous processes of the vertebræ does not depend on their being driven backwards and dislocated, when their bodies are absorbed, it is only necessary to observe the real directions taken by them, as exhibited in the numerous morbid preparations in the museums of the metropolitan hospitals. Thus we observe, in Figs. 47 and 48, that the positions of the spinous processes resulting from absorption of the bodies of the vertebræ are not relatively altered, except by the vertebræ being compelled to rotate in the mesial plane. The humped back is owing to that part of the spine which rests upon the diseased portion being thrown forwards, and the amount of the deformity depends upon the number of bodies diseased, and the degree and direction of the absorption; and such will be found to be the relative

positions of the vertebræ in all, or nearly all, the morbid specimens in London.* When anchylosis begins to take place between the vertebræ, before any considerable portion of the bodies is absorbed, the distortion will be comparatively trifling,

Abstract of Case. (Fig 48).—Thomas V——, aged thirty-nine years; admitted July 10th; died July 11th, 1839.

Autopsy.—The lower extremities were swollen and anasarcous; the lungs adhered to the pleura; the heart was nearly double the natural size, owing principally to the dilatation of its cavities, its walls being only slightly hypertrophied, and the valves healthy; the peritonæum was thickened, and contained six quarts of opaque serum; the liver was congested with blood, and presented a nutmeg appearance; the spleen was small; the kidneys were natural; the stomach was closely attached to the liver by peritoneal adhesions; the mucous membrane of the large and small intestines was vascular, but otherwise healthy; the bodies of the ninth, tenth, eleventh, and twelfth vertebræ were destroyed, and anchylosis had taken place.

Remarks.—This is a case of extreme angular curvature, the trunk being bent at an angle greater than 45°; the patient, nevertheless, lived beyond the mean term of human life.

It often happens that, among several diseased bones,

* This may be familiarly illustrated by bending a pen, the plume of which represents the spinous processes.

Fig, 47.

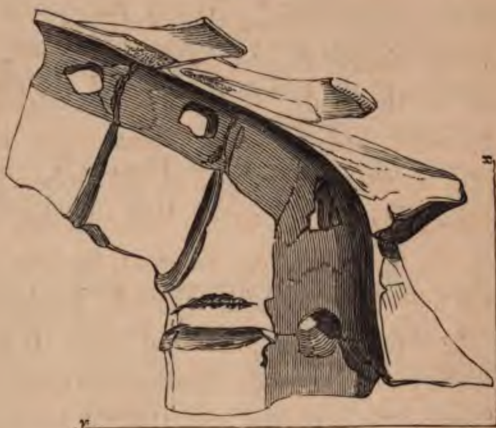


FIG. 47.—*Guy's Hospital Museum,* No. 1024[25]. Abscess, and partial absorption of the bodies of two dorsal vertebræ, producing curvature of the vertebral column ; lines *y* and *x* as in fig. 47.

Fig. 48.

FIG. 48.—*Guy's Hospital Museum,* No. 1020[25]. Specimen of a mesial section of some dorsal and lumbar vertebræ, six of which are completely consolidated into one bone, with extreme angular 'on ; *y* and *x* are horizontal and vertical lines.

the amount of absorption is variable, those nearest the centre of the curve suffering the most.*

When the disease begins in the superior or inferior processes of the body, the adjoining intervertebral cartilages must necessarily be destroyed; but, if it commences on the anterior face of the bone, this does not necessarily take place to the same extent, and the effects on the figure are very different, for some of these cartilages may be absorbed, without producing any sensible distortion of the spine (Fig. 49). It has been shewn in Chapter II., that the figure of the spine depends on the form of the vertebræ, and that the intervertebral cartilages merely endow it with elasticity; hence, when the cartilages between three or four vertebræ are destroyed, the figure suffers but very slightly compared with what happens when the bodies of the bones are destroyed. In some cases, the absence of the cartilage is supplied by other matter, which fills up the vacant spaces, and the bones become anchylosed. In others, the intervertebral cartilages are hypertrophied, and force the bodies farther from each other, whereby the person virtually becomes taller, as in Fig. 50.

Abstract of Case. (Fig. 50.)—Samuel D——, aged forty-eight years, was admitted under Mr. Key, Oct. 21st, 1835, and died Jan. 4th, 1836. This was a

* The author takes this opportunity of expressing his thanks for the advantage which he has derived in being allowed free access to the museums of several of the London hospitals, as well as for the permission to make drawings of such morbid specimens contained in them, as illustrate his views in this work.

very complicated case, including fistulous stricture, paraplegia, hypertrophied intervertebral substance,

Fig. 49.

Fig. 49.—*St. George's Hospital Museum*, No c. 3. Ulceration of intervertebral cartilages without deformity.

Fig. 50.

FIG. 50.—*Guy's Hospital Museum,* No. 1289[48]. Hypertrophy, and partial ossification of intervertebral cartilages.

diseased hip-joint, exostosis, psoas abscess, dysentery, peritonitis, fæcal abscess, and hypertrophied kidney, attended with delirium, and terminating in death.

Autopsy.—The chest presented nothing remarkable; the spleen was natural, but its capsule was discoloured, separated by a fluid, and connected with an abscess; the peritoneum was vascular, with partial adhesions, but there was no visible effusion; the colon was ulcerated, and perforated by many apertures; pus was found lodged in folds of the peritoneum, lying in front of the left kidney; the kidneys were of unequal size, the lesser containing three or four minute portions, which had suppurated; the prostate gland was small and firm; the urethra thickened, and contracted near the middle of the penis, with a sinus leading to the perineum; there was a psoas abscess on the right side, reaching to the origin of the muscle; the right hip-joint was filled with pus; the head of the femur was hypertrophied; the ligamentum teres gone, and the neck of the bone encircled with exostoses; the vertebræ were not ulcerated, but the lumbar region was slightly incurvated on the right side; the intervertebral substance was hypertrophied, and partially ossified; and the bodies of the adjacent bones presented irregular patches of exostosis. Between the second and third lumbar vertebræ, the osseous matter projected into the vertebral canal, and pressed on the spinal cord: the canal was diminished at this part to one-third or one-fifth of its natural size.

Remarks.—In consequence of the patient being

affected with so great an amount of disease, he was sleepless, and frequently delirious, a condition which was doubtless much aggravated by the pressure on the spinal cord. He was treated with astringents for the diarrhœa, and with opiates to allay the spino-cerebral irritation.

In other cases these cartilages are absorbed, and the bones come in contact. This condition may be detected by the crepitus emitted on twisting the body laterally, also by the pain induced, and by the absence of deformity, which symptoms will assist us in forming a correct diagnosis. Notwithstanding the great extent to which the vertebræ are often destroyed by caries, it has always excited surprise how so much damage can occur without producing the most serious effects on the structure and functions of the spinal portion of the nervous system; but it must be remembered that the structure of the vertebræ is not uniform, that those portions which are destined to protect the spinal cord and nerves are much denser and harder than the body of the bone, and also less vascular, and therefore less liable to disease: hence we often find the body in a state of active organic disease, without the other portions of the bone being affected. The notches in the bones, through which the nerves pass from the spinal cord, are situated in the harder portions of the bone, and are thereby protected from injury, even when the body of the bone has been destroyed. When the bodies of six or seven consecutive vertebræ are destroyed, and the body of the patient is bent forwards, as in Fig. 48, we are

likewise led to inquire how it is that the spinal cord is not injured. If a mesial section be made through the diseased bones, as in Fig. 47, it will be observed that not only is the vertebral canal entire, but that, in fact, its area is largest at the bend—an arrangement which tends most effectually to protect the spinal cord; but this end is obtained only by the consolidation and anchylosis of the several remaining portions of the diseased bones. This is the most natural and most desirable termination of caries of the vertebral column, and when effected, it leaves the osseous system otherwise in a healthy state. The chief evils which result are the changes which the figure of the person undergoes, and the effects produced in those regions of the body which are connected with the several parts so changed. When the disease of the vertebræ continues, and no disposition to anchylosis can be induced, the malady assumes a more formidable character; the bodies waste away, leaving a great chasm between the vertebræ in parts (Fig. 51), and often exposing the sheath of the cord. This sometimes happens in scrofulous and syphilitic persons, and a train of constitutional derangements ensues, ending only with the death of the patient.

In some of the more severe forms of caries of the spine, the disease is not confined entirely to the cancellated portions of the bone, but extends to the harder and denser lamellated structure, of which the arches and processes are chiefly composed. This occasionally happens when the disease attacks the cervical vertebræ,

Fig. 51.

FIG. 51.—*St. George's Hospital Museum,* No. c. 12. Caries of

several of the vertebræ, the body of one being entirely destroyed; anchylosis had not taken place. *x*, a vertical line, and *x′* the direction which the spine must take when the remaining portions of bone lie in contact.

but may take place in any portion of the vertebral column. In these cases, the patient very rarely survives the attack. A case of diseased cervical vertebræ in a boy, twelve years old, is related by Lebert. The child used the recumbent position. Every movement of the head was accompanied with great pain. The spine was bent, and a fistulous opening, opposite the fourth vertebra, led to the diseased bone. The patient was greatly emaciated, and on one occasion, when moving the head, he was seized with convulsions, and died.

Autopsy.—The lungs were found free from tuberculous deposit, and the left ventricle of the heart was hypertrophied. The cervical vertebræ were diseased in their whole extent, the caries being arrested only at the condyles of the occipital bone. The bodies of the vertebræ were chiefly affected, being in part destroyed, blackened, and softened, and presented some detached pieces of bone. The diseased portions were surrounded with a yellow lardaceous tissue. The brain was of the ordinary consistence, with some venous congestion of the superior part of the right side, and a milky-coloured serous fluid was found in the arachnoid membrane. The spinal cord was sound, and the pus in the vertebræ, on being inspected under the microscope, was found to be free from tuberculous matter.

Another case, mentioned by the same author, is

worth recording on account of the morbid appearances exhibited on a microscopic inspection of the carious vertebræ after death. A man, aged forty-eight years, of a strumous habit, was affected with lateral curvature of the spine at the first lumbar vertebra, and several of those adjacent to it were displaced from their normal position. There was a psoas abscess in the right groin, which was not opened during life. He presented occasionally symptoms of partial paraplegia. Towards the termination he had cough, with signs of tubercular consumption, and died of pleuro-pneumonia.

Autopsy.—The lumbar vertebræ were found diseased at their anterior part; the cellular tissue was atrophied; the walls of the bodies were infiltrated with pus, and had cavities wherein detached pieces of bone were found; the surrounding surfaces of the vertebræ were softened, so that they were easily cut with a scalpel. In the most diseased parts a fistulous channel was found, connected with pouches, pouring out on the psoas and iliacus muscles purulent matter which gravitated to the groin. A pyogenic membrane, two millimetres in thickness, was found in the bone, of a pale-red colour in some places, and of a slate colour, presenting a velvety appearance, in others. It was folded, and could be easily detached from the bone. The pus of the abscess was of a pale-yellow colour; the serum had been almost entirely absorbed when it was placed under the microscope. There were found—first, globules of pus, varying in size from $0.^{mm}\cdot008$ to $0.^{mm}\cdot011$; secondly, large granular

globules, varying from $0.^{mm}\cdot02$ to $0.^{mm}\cdot25$; and also numerous fatty vesicles. In some parts, the concrete pus was of a consistence that rendered it capable of being sliced with a scalpel; it contained fibrinous matter, which, according to Lebert, was probably derived from the fibrin of the purulent coagulated serum. In those portions of the vertebræ in which the ulcerative process had not yet taken place, there were found softened portions, with great vascularity of the parts, and pus in different states. Between the vertebræ which were most diseased, there was a red liquid, composed of the detritus of the diseased bones, calcareous salts, globules of blood and of pus. The pyogenic membrane contained numerous vessels, the smallest of which were $0.^{mm}\cdot025$.

The morbid anatomy of carious diseases of the bodies of the vertebræ tends to show that the attack may commence either at the surface, or in the internal structure of the body, and that its early stages are associated with an inflammatory condition of the parts. The capillaries being gorged with blood do not yield a supply of nutriment, but exude purulent matter, which ends in the production of an abscess. In general, this exudation takes place through a very great number of capillaries, which are separated from each other by lamellæ and canals of bony structure; the areolæ of the bone become infiltrated with pus, which hardens, and is partially absorbed when the inflammatory process is arrested, and it then sometimes assumes the appearance of a miliary tubercle. This inflammatory

condition of the capillaries, exuding pus, and diminishing the deposit of nutritive matter, whilst the process of absorption continues, must cause the wasting of the bones. As the deposition of pus continues, the areolæ are dilated and absorbed, and the matter issues from the interior of the bone by fistulous openings. According to Lebert, the capillaries also exude a liquid, which becomes organized into a plastic tissue that destroys the osseous areolæ. This tunic, being very vascular, furnishes a secretion which continually moistens the fistulous openings and diseased portions of the bone. The origin of these inflammatory conditions of the bones, when it is not occasioned by violence, Lebert considers due to an altered condition of the blood itself, especially to a tuberculous dyscrasy, although the bones are very rarely subject to tuberculization.

The few distinguished surgeons who have devoted any attention to the pathology of caries seem to have entertained very vague notions of the nature of this disease. Mr. Pott, for instance,—considered a great authority in these matters,—observes, that "the primary and sole cause of all the mischief is a distempered state of the parts composing, or in immediate connexion with the spine, and most frequently ending in caries of one or more vertebræ: from this proceed all the ills, whether general, local, apparent, or concealed. This causes the ill health of the patient, and, in time, the curvature." The view here taken does not advance us a single step in the discovery of the cause of caries, and

is perfectly useless; in fact, an explanation in which nothing is explained, effects being made to stand in the stead of causes. Sir Benjamin Brodie considers that the pathological history of caries may be arranged under three heads:*—First, "It has its origin in that peculiar softened and otherwise altered condition of the bodies of the vertebræ which seems to be connected with what is called a scrofulous state of the constitution. In these cases, ulceration may begin on any part of the surface, or even in the centre of the bone; but in general the first effects of it are perceptible where the intervertebral cartilage is connected with it, and in the intervertebral cartilage itself." Secondly: "In other cases, the vertebræ retain their natural texture and hardness; and the first indication of the disease is ulceration of one or more of the intervertebral cartilages, and of the surfaces of the bone with which they are connected." Thirdly: Another order of caries, but of more rare occurrence, "in which the bodies of the vertebræ are affected with chronic inflammation, of which ulceration of the intervertebral cartilages is the consequence." It will here be observed, that Sir Benjamin Brodie is of opinion that caries arises in the body of the vertebræ, and is associated with a scrofulous constitution. This opinion furnishes views of a far more definite nature than those contained in the statement of Mr. Pott, but leaves to future investigators the complete solution of the pro-

* Diseases of the Joints, p. 243.

blem—namely, the determination of the cause of the disease. Dupuytren appears to have entered this field of inquiry by first asking himself, "What is the origin of this singular alteration, and to what class of lesions is it to be referred? Why is its progress so slow? Wherefore should it select the vertebral column for its attacks; and why should its existence in this part remain hidden, until revealed by the presence of pus at a considerable distance from the seat of the disease?" He then states, that the solution of the difficulties which surround the subject is to be sought for in the illustration afforded by cases. He considers that the anatomical changes may be referred to three heads—first, internal suppuration, which is the origin of symptomatic abscess; secondly, deep-seated suppuration in contact with the bones, involving a separation of the adjacent fibrous texture; thirdly, a change in the bones themselves. In six cases examined by him, the fibrous tissues which strengthen the vertebral column were dense, and thickened, and presented evidence of chronic inflammation; the periosteum was stripped off to a variable extent, and pus was found deposited between the denuded bone, and the tissues by which it is naturally surrounded. In almost every case there existed an extensive but more superficial suppuration along the muscles and vessels, the pus being without fœtor, and not sanious, as in scrofulous cases, but homogeneous and healthy, such as is the result of simple inflammation. In a large number of morbid cases, examined for Dupuytren by M. Dalmas, the

latter remarked that there never existed any definite relation between the amount of disease affecting the bones, and the extent of the external disorder; for, in some cases, the bones were diseased only at a single point, while the affection of the adjacent textures was very considerable; whereas, in other cases, five or six vertebræ were denuded and bathed in pus, while the surrounding parts were healthy. Dupuytren further remarks, that caries, considered in the abstract, consists in a simple denudation of the bone, accompanied with an erosion, and, consequently, an irregularity of surface, the dark colour of which is apparently an adventitious circumstance, dependent on the admission of air and the contact of pus, the bodies of the vertebræ and the intervertebral cartilages being sometimes destroyed; a more rare result being a thinning or wasting of the osseous texture. From this account, it is clear that Dupuytren has overlooked all the premonitory symptoms of the formation of caries, and the condition of the patient while the causes of mischief are being developed. The origin and progress of these affections are known to be insidious; but there is a chain of symptoms significant of the seat and nature of the malady, which might be detected when the patient is carefully examined. He has not solved his own questions relative to the slow progress of the disease, nor why it should more frequently invade the vertebral column than other portions of the skeleton.

CHAPTER X.

CARIES, CANCER, AND ENCHONDROMA OF THE BONES.

Consideration of the questions of Dupuytren.—Cases in illustration.—Caries of the great toe.—Microscopic appearances of the diseased parts.—Case of caries affecting the spinal cord, producing paralysis.—Death of the patient.—Morbid appearances.—Caries.—Angular curvature of the spinal column.—Effects of transient pressure on the spinal cord.—Views of Bonnet; of Boyer.—Association of caries with scorbutic, syphilitic, scrofulous, and cancerous taints.—Enchondroma, description of.—Theory of Muller.—Microscopic examination of its structure.

If we revert to two of the questions propounded by Dupuytren, and mentioned in page 173—namely, Why does caries select the vertebral column for its attacks? and why is its progress so slow?—it is obvious that their solution involves an inquiry into the organization and functions of the vertebral column. On the first of these questions we may remark, that the morbid specimens of diseased vertebræ show that the disorder generally commences in the areolated portions of their body, which, being softer and more vascular than other bones, must be more liable to inflammatory action. An investigation of the unequal pressure, likewise, and

of the shocks and blows which are incidental to the position and office of the spine, may lead to the solution of the question under consideration in each particular case. It is very common for children, especially boys, to give and receive blows on the back, which pass unnoticed at the time, but which may be quite sufficient to set up a morbid action in the bones of persons predisposed to caries. Violent gymnastic exercises, such as leaping, throwing the body from heights, and many other accidental circumstances, may suffice to induce this disease in the spine, especially where combined with constitutional predisposition. The following is a case illustrative of the preceding remark.

A mail-guard on one of the railways, aged about twenty-five years, of a scrofulous habit, consulted the author on account of a spinal curvature in the mesial plane, produced by a partial absorption of several of the bodies of the superior dorsal vertebræ, which terminated in anchylosis of the remaining portions of the bodies. He stated that he had enjoyed excellent health until about the age of puberty, when he received a blow on the back, at the part described. The effect of the blow was an inflammatory action in the bodies of several vertebræ, ending in the deformity above mentioned. He himself seemed thoroughly convinced that the disease originated in the blow; and since the mischief became apparent immediately after it, there is little doubt but that the blow deter-

mined the morbid action in a constitution predisposed to caries.

With respect to Dupuytren's second question, we may observe that the diseases of the bones in general are less rapid in their progress than those of the softer tissues, as might be expected from the well-known slowness of the normal assimilation and absorption of the earthy constituents of bones: we may, indeed, reasonably infer, that since they are less vascular, and contain fewer absorbent vessels than the softer tissues, the processes of inflammation, suppuration, and absorption, will likewise be proportionably slow. Other bones of the skeleton, however, are sometimes affected with caries, while the vertebral column is perfectly sound; and in some of these cases there is an opportunity of observing the mode of action of the disease during life.

It sometimes happens that the bones of the extremities are affected with caries, and that the constitutional symptoms indicate the necessity of removing the limb. An inspection of the diseased portions will give information as to the nature of the action going on at the time. A case of caries of the great toe, occurring in a man fifty years old, is related by Lebert, in which the soft parts were considerably disorganized, and it became necessary to amputate the limb. On inspection, the diseased parts presented the following appearances:—The corpuscles proper to the osseous tissues had, in a great measure, disappeared, and those which remained were much altered in cha-

racter; the areolæ were thin, softened, and dilated, of a grey hue, and filled with "*tissus d'exsudation;*" the lamellated structure had nearly disappeared, and the structure of the bone had become so soft as to be readily cut into small thin pieces by the scalpel.

The "*tissu d'exsudation,*" according to Lebert, takes its origin in the medullary membrane of the areolæ, and is the "*tissu muqueux accidentel*" of Lisfranc: its appearance is smooth, tolerably vascular, and of a reddish-yellow colour. On being examined with the microscope, the following structures were found:—First: A substance delicately fibrous, hyaline or granulous between the intervals of the fibres. Secondly: Numerous small globules, $0.^{mm}005$ in size, which appear, at first sight, to be the principal element, but on closer examination they are found to be the nuclei of larger globules, of a magnitude from $0.^{mm}0125$ to $0.^{mm}015$, having a pale exterior, which is not altered by the action of acetic acid.

From these and other microscopic examinations, it seems that, during the progress of the disease, there is not only a destructive process of inflammation, suppuration, and absorption of the bones going on, but also the formation of newly-organized secreting tissues, which exercise a destructive influence on the surrounding parts, and confer on them a malignant character. From his own researches, Lebert has arrived at the conclusion that there are no tubercles found in the diseased bones in any of the stages of caries, although the lungs may, in the same patient,

be tuberculous. The vertebral column, as we have seen in Chap. IX., is so constituted as to protect the spinal cord, even when the bodies of several successive vertebræ are destroyed. The cord, however, does not always escape the injurious effects with which it is threatened by the derangement of its osseous covering.

Sometimes the spinal cord is diseased along with the bone; or it may be pressed upon, in consequence of the wasting of the bodies of the vertebræ; or it may be irritated and affected by extraneous injuries, such as blows. The following cases will serve to illustrate these several conditions.

CARIES, WITH SUPPURATION OF THE SPINAL CORD.

Case I.—Amelia H——, at the age of ten years, began to lose the natural colour of the cheeks; the face and throat were swollen towards night; complained of pain in the left side, and could not lie down during a space of three months; consulted the late Mr. Thomas, who stated that the heart and pericardium were affected; afterwards consulted Drs. Latham and Harrison, and was advised by the latter to use the recumbent position. At twelve years old, symptoms of curvature of the spine began to be apparent by the falling forwards of the shoulders, and the projection of the spinous processes of several of the dorsal vertebræ. After remaining in a delicate state two or three years, her health improved so very much, that she was enabled to hold a situation at the Pantheon Bazaar for several years. After this she relapsed, and was

obliged to abandon her employment. She then experienced a difficulty in swallowing, and gradually lost the power of motion in the lower extremities She was put under the care of Dr. Verral, and was placed on the inclined plane, in the prone position. She was kept on this plane, day and night, during the period of a year and ten months, and subsequently for short periods during the day, and always at night. Under this plan of treatment she gradually got worse, and symptoms of pulmonary phthisis presented themselves, with cough and muco-purulent expectoration from the lungs; the legs were red, swollen, and œdematous; sensation imperfect, and motion entirely lost. In this deplorable condition she was placed under the author's care. Finding that the prone position tended to aggravate the affection of the lower extremities, she was removed from it to a triple-inclined plane, and kept in a recumbent posture, the trunk being elevated by raising the head-piece of the plane to an angle of 45°. Appropriate remedies were employed, with the view of improving the state of the constitution. In the course of a few months, however, the pulmonary complaint put an end to her sufferings. She died on the 14th of April, 1845, at the age of twenty-six years.

Sectio cadaveris.—The spinal canal was laid open behind by removing the arches of the lower cervical and upper dorsal vertebræ.* The arches of the fourth and fifth dorsal vertebræ were found in a state of caries, the bodies being partly absorbed. A quantity

* The morbid structure of the parts was sent to the Hunterian Museum.

of pus was thrown out, and pressed on the sheath of the cord posteriorly. At those parts which lay in juxtaposition with the diseased bodies of the vertebræ, anteriorly, the sheath was inflamed and diseased. On making a longitudinal incision into the spinal cord, opposite the diseased bones, a large quantity of pus flowed out from the central portions. The substance of the cord was found to be softened, and of a reddish colour, presenting the aspect of the morbid appearance termed by French anatomists "ramollissement rouge." This was a case of progressive caries, with disease of the cord and sheath, in which there was no disposition in the vertebræ to anchylose, and which continued during a period of sixteen years, producing the effects above detailed; but as the patient died from an affection of the lungs, it is difficult to determine how much longer life would have lasted, had the caries been the only malady under which she laboured.

The difficult deglutition, and the paralyzed condition of the lower extremities, are some of the most aggravated effects of this serious form of caries, and they may be considered as the symptoms especially due to the peculiar morbid state of the spinal cord, while the irritable state of the nervous system generally, the loss of sleep, night sweats, loss of appetite, and irregularity of bowels, are common to other forms of caries, unaccompanied with this peculiar condition of the cord.

CARIES, PRODUCING PRESSURE ON THE SPINAL CORD.

Case II.—Henry A——, aged fourteen years, was admitted under the author's care, at the Islington

Dispensary, Oct. 24th, 1842. He stated that he had been suffering from an affection of the spine during four years, with scrofulous abscesses on the hips and thighs, and had been confined to his bed nearly the whole of the time. On examination, it was found that the bodies of several of the dorsal vertebræ were diseased, some of which had been partially, and others entirely absorbed, and the whole dorsal region presented a large curve in the mesial plane of the body, as seen in Fig. 52. When placed in the vertical

Fig. 52.

Fig. 52.—A case of angular curvature producing pressure on the spinal cord.

position, the legs were spasmodically drawn across each other, which prevented his either walking, or even standing. Large scrofulous ulcers poured out pus in large quantities from the neighbourhood of the right hip-joint, the joint itself not being implicated in the disease. His figure was short, as in rickets; countenance pale and cadaverous, and body thin and emaciated; his head large; eyes full, and expressive of intelligence; his mind active. Pressure on the back over the seat of disease produced no pain. The sensibility of the lower extremities was unimpaired; his rest was broken during the night, and he suffered from continued nervous excitement.

He was placed on a triple-inclined plane, the angle of each plane being adjusted to suit the nature of the case; the wounds were dressed with the nitric oxide of mercury ointment twice a day, and a carrot poultice was applied over this dressing every night, to correct the fœtor of the pus discharged. A mixture of iodine and iron, composed as follows, was given three times a day:—Sesquioxide of iron and compound tincture of iodine, of each one drachm; tincture of columba, one ounce; cinnamon water, eight ounces. Under this treatment, the wounds in a short time assumed a more healthy aspect, and in a few months healed; the nervous irritability gradually subsided, and the general health improved. In this state he was seized with an attack of confluent small-pox, which left his face very much disfigured. When he had rallied from the effects of this attack, he resumed the mixture, and

still remained on the inclined plane. After the lapse of eighteen months, the disease of the bodies of the vertebræ was arrested, and the general health was restored; but the absorption of bone had left the anterior column of the spinal cord subject to pressure in standing, and, consequently, the legs spasmodically affected as before.

Remarks.—During the treatment, the magnitude of the curvature was measured from time to time, by which means it was found that the ordinates of the spinal curve did not increase; consequently the absorption of the bones must have been arrested shortly after the commencement of the treatment. In this patient, the disproportion between the size of the head and length of the body (the stature being very short for his age), the carious state of the vertebræ, and the scrofulous abscesses, tended to show the mixed nature of the complaint, there being, at the same time, symptoms of caries, of rickets, and of scrofula. The spasmodic crossing of the legs proved the existence, in this instance, of irritation, resulting most probably from slight pressure on the anterior column of the spinal cord. It was satisfactory to observe the local and general symptoms yielding to the treatment adopted, except the spasmodic affection, which showed that the diseased vertebræ did not perfectly anchylose.

EFFECTS OF A BLOW ON THE BACK.

Case III.—A boy, aged nine years, was admitted into the Islington Dispensary. He complained of pain

in the back part of the neck and head; his countenance betrayed great anxiety; he was restless, his respiration laborious, and his deglutition performed with great difficulty. It was stated that he had been struck by his father, a few days before, with a small deal rod about an inch thick, but which did not produce any effects sufficient to attract attention until two days afterwards, when the symptoms already described came on. Leeches were ordered to be applied to the back of the neck, cathartic medicines to be administered, and rigidly antiphlogistic measures to be adopted. But within a few hours he fell into a comatose state, and died.

Autopsy.—The sheath of the spinal cord having been laid open opposite the part where the blow had been given, the integuments presented no trace of contusion; the vertebræ of the back, in general, were somewhat of a soft, spongy texture. On exposing the spinal cord, no trace whatever of the effects of the blow could be perceived; but on examining the cervical region, the membranes of the cord presented slight traces of inflammation, which increased very sensibly as the sheath of the medulla oblongata and membrane of the brain were brought into view. Fluid was found lying between the medulla and sheath, and also in the lateral ventricles. The dura mater and pia mater were very vascular, and showed signs of acute inflammation.

Remarks.—The pressure of the fluid on the medulla oblongata sufficiently accounts for the disturbance of

the functions of respiration and deglutition, and the speedy death of the patient. One of the most remarkable features in this case is the circumstance of the apparent absence of any inflammatory symptoms in the cord at that part of the back where the blow was said to be struck, and the transmission of its effects to a distance—namely, from the spinal to the cerebral system. We know from experience that irritation of the peripheral branches of a nerve may be transmitted to the centre of the nervous system, and induce a morbid change in it,—an effect analogous to that above described.

Portal states that M. Troia, a surgeon of Naples, has proved that in cases examined by himself, the spinal cord had been primarily diseased, and the bones secondarily. The investigations which have been made of the morbid specimens of carious bone tend to show, that under the same appellations specific and distinct actions are included, and different products are evolved in different individuals; some terminating in complete destruction and absorption of the parts affected, others in partial destruction and anchylosis of the remainder; some, again, attacking the medullary portions of the bones, others the superficies, and ending in necrosis. Supposing, therefore, the general derangement of the system to be nearly the same in all these different states, there must undoubtedly be some specific cause to determine each particular kind. Bonnet states that he has made researches into the writings of authors of authority on caries, in order to

ascertain their views respecting the difference between caries and necrosis, but that he could not succeed in clearing up this point. Boyer and Sanson, for example, classed caries of the cellular structure of the short bones with necrosis of the compact tissue of the middle of the long bones. This problem, he contends, may be easily resolved by applying the knowledge we possess of the elementary lesions of the bones to the mode in which these lesions are effected. His solution of this question is, that "caries of the extremities, and necrosis of the central parts, ordinarily succeed suppuration; only, in the first case, the suppuration is produced in the cellular tissue; in the second, in the medullary canal; and whichever of these two tissues it may occupy, it involves the death of that part of the bone in which it exists. Around the mortified portions, secretions of organizable matter are thrown out, one portion of which is converted into bone, and the other remains in a fungoid state, accompanied with secretions of pus; and ultimately ulcerations take place, through which these secretions exude.

But although so close an analogy subsists between the consequences which follow suppurations of the medullary canal, and those of the cellular tissue, it is impossible to mistake the difference between them. Thus the mortified parts about the medullary canal, in a state of suppuration, are as solid as the compact tissue itself; those in the medullary tissue are porous, and resemble that tissue. In short, around

the mortifications resulting from maladies of the medullary membrane, the sound periosteum ossifies; while in disease of the cellular tissue, the periosteum, being impaired, becomes ossified only at a certain distance from the principal lesion. Boyer defines caries to be a malady of which we cannot give a better idea than by comparing it to bad ulcers and an internal disease (*vice*), attacking the soft parts; but he admits that this comparison,—"laisse encore néamoins beaucoup de choses à desirer," and, moreover, that the changes which belong to caries, and are going on in the internal organization of the bone, cannot often be discriminated by the symptoms exhibited. It may here be inquired whether Boyer had ever paid sufficient attention to the early symptoms of the disease; for it cannot be denied that there is in reality a class of symptoms preceding its actual development, before it is made manifest in the wasting of the bones. Many of these symptoms may, undoubtedly, be common to those exhibited in other complaints; but there are others which belong specifically to caries. Independently of blows, which may produce either caries, exostoses, or necroses, Boyer considers scorbutic, scrofulous, syphilitic, and cancerous affections to be predisposing causes of caries. The effects of these will be best described in his own words.*

* "Le vice scorbutique, tout en diminuant la force contractile des organes musculaires, porte un principe de dissolution dans nos solides et dans nos humeurs; la fluidité du sang augmente, elle transude facilement à travers les mailles relâchées du tissu

But, if we suppose with Boyer that these several affections are followed by the effects which he has described, they must still themselves be the result of some prior morbid condition of the system, which must be investigated, in order to ascertain the real origin of the disease. The physio-pathological causes of syphilis, scrofula, cancer, &c., and the modes in which they act in producing these diseases, are problems hitherto unresolved,— all that is yet known on these points being some of the conditions favourable for their development. No one has yet attained the solution of these questions, or, indeed, discriminated

de ses petits vaisseaux, des taches ou ecchymoses scorbutiques se manifestent, d'abord dans les lieux les plus éloignes du centre circulatoire comme les jambes et les pieds; les muscles se ramollissent et deviennent douloureux; les gencives se gonflent et se détachent des bords alvéolaires: le perioste des os, auquel ces membranes doivent être comparées, peut également se gonfler et se décoller de leur surface qui se carie. Il en est de même du vice scrofuleux qui porte ses ravages sur le système lymphatique, et sur les parties spongieuses des os: delà naissent les caries scrophuleuses, caries qu'un gonfflement lymphatique précede, et qui fournissent un pus noirâtre et abondant par les fistules intarissables.

"Le virus venerien, quoique donnant lieu le plus communément à l'exostôse et la necrôse, produit aussi la carie: c'est ainsi que les os propres du nez rongés par elle, s'éncrassent, et que cette partie éprouve une déformation hideuse.

"Le vice cancereux peut-être cause la carie; cela arrive quand un ulcère de cette nature a son siège au voisinage d'un os, c'est ainsi qu'on voit les côtes et le sternum se carier dans les cancers ulcérés des mamelles."

whether they are mechanical, chemical, vital, or a combination of any or all of them; which points, however, are necessary to be determined before any person can be in a condition to form a correct hypothesis upon the subject. It is of great importance to search out and understand clearly the nature of the problem which we have to consider; for it is the want of attention to this preliminary step in the various questions with which the medical profession has to deal, that has occasioned such a laxity of reasoning in medical literature.

When caries of the bones is a consequence of any previous disorganization,—such, for example, as those enumerated by Boyer,—the constitutional treatment must necessarily be the same as that of the previously existing disease. When the origin of the disease can be certainly traced either to a scrofulous, syphilitic, or other specific malady, the treatment is clearly indicated. In the majority of the cases of caries, there is unquestionably a scrofulous taint, which is rendered apparent by the existence of scrofulous ulcers and indurated glands. In like manner, there are sufficient symptoms of a specific nature to enable us to determine whether the case is, or is not, owing to a syphilitic taint. The spongy structure of the bones in scrofulous patients, wherever it is found, is liable to be affected with caries, which accordingly attacks the short bones, such as the tarsus, carpus, the bodies of the vertebræ, and the spongy ends of the long bones. In syphilis, the hard laminated portions are more frequently dis-

eased, generally the palate and nasal bones. The views of Boyer lead to the conclusion, that caries is only an occasional result, arising from one of the several diseases enumerated; for we know that all those diseases may exist without caries. Troia considers it, on the contrary, to be consequent on some morbid condition of the spinal cord, and does not, like Boyer, attribute it either to scorbutic, syphiloid, scrofulous, or cancerous taints. There are, undoubtedly, many independent and distinct causes producing this disease; for we find, in treatises of pathology and morbid anatomy, under the term caries, cases presenting a variety of independent external phenomena, and different internal derangements of the system; likewise, reports of morbid states of bones, exhibiting, under the microscope, a variety of different products. The symptoms in syphilis, cancer, and scrofula, are, indeed, sufficiently distinct in their external form to enable the surgeon to distinguish to which of the maladies the caries should be attributed. It has been seen that in none of the morbid specimens examined by Lebert was any tubercular deposit detected in the diseased bones, although it is well known that caries frequently exists contemporaneously with tubercles developed in the lungs and other parts of the system. These tubercles may likewise exist at the same time with fungoid tumours, a fact which has been verified by the aid of the microscope, the corpuscles of scirrhus and encephaloid tumours being sufficiently distinct from those of tubercle to be easily discriminated by

means of that instrument. In an infant four years old, Lebert found tubercular deposits in the brain and lungs co-existing with encephaloid tumours in the right kidney; and in a woman, aged sixty, he found scirrhous breasts co-existing with tubercles of the lungs, proving the incorrectness of the hypothesis, that tubercle and scirrhus mutually prevent the formation of each other in the system. From what has been stated, we arrive at the conclusion, that caries, in its simplest form, arises from inflammation and ulceration of the bone, produced by extraneous force, and that it may be the consequence of other diseases, some of which admit of a remedy, and others, in the present state of our medical science, are incurable.

Besides caries, necrosis, rickets, and mollities ossium, inflammatory and other states of the bones sometimes occur, terminating in hypertrophy, or in the formation of erectile, cartilaginous, and sarcomatous tumours. The latter of these may have their seat either at the superficies or in the interior of the bone. When they occur on the surface of the tubular, or flat bones, they receive a slight support from a peculiar skeleton, formed of very delicate spiculæ or laminæ of bone, which, proceeding in a radiated manner from the surface of the bone, penetrate into the interior of the soft tumour.* But Müller states that these spiculæ are not infallible proofs of the cancerous nature of fungoid exostosis, and he says that medullary fungus not only fills up the cavity of the bone, but induces a state of

* See Carswell's Pathological Anatomy.

atrophy of the osseous tissue, and reduces the substance of the bone to a mere shell, so that the slightest cause is sufficient to produce fracture. According to Lebert, medullary sarcoma, or the encephaloid forms of cancer, are those which most frequently attack the osseous textures, and they occur in one of two states—namely, that of cancerous tumour, and that of infiltration, both of which may take their origin either in the medullary or in the cancellated structure.* This form of disease sometimes begins deep in the bodies of the vertebræ, as in fig. 53. It has also been figured and described by Carswell,† Ebermaier,‡ Cruveilhier,§ Gluge,‖ and others. The formative globules of this variety of morbid product are regarded by Gluge as very similar to those of common cancer, and to those which form the grey mass of carcinoma reticulare; and thus the cases of common caries may be distinguished from cancer, by the absence of the cells peculiar to the latter. It is not usual for pathologists, with the exception of Boyer, to class cancerous affections of the bones along with caries, such as we find it in scrofulous

* Dr. Walshe remarks, that "posterior prominence of the spinous processes of the vertebræ, which has undergone cancerous destruction, has been observed, and is explicable in the same manner as the like phenomena in caries."—*The Nature and Treatment of Cancer*, p. 528.

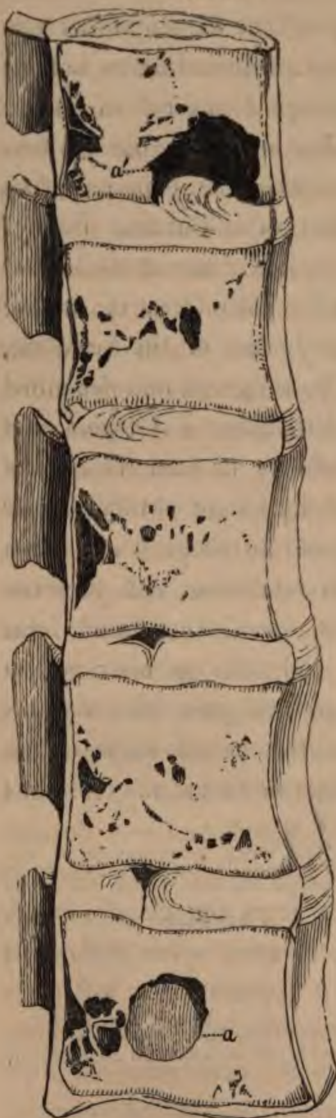
† Pathological Anatomy, fasc. iii. plate 4, figs. 1 and 2.

‡ Ueber den Schwamm der Schädelknocken und Düsseldorf, 1829, Taf. vii. viii.

§ Anat. Pathol., livr. xxiii. plates 5 and 6.

‖ L'Institut, No. 191, 1837.

Fig. 53.



constitutions, inasmuch as the former is a malignant disease occurring in a constitution affected with an incurable malady; whereas the latter often lasts in the system during a stated period only. Cruveilhier has remarked, and the observation is confirmed by Mr. Hilton, that when encephaloid tumours of the bones have been discovered in one part of the skeleton, they have often also been found in other bones in the same person. These malignant diseases, however, not only cause the destruction of the bone, but involve the soft surrounding tissues either primarily or secondarily, and ultimately destroy life. It is, therefore,

FIG. 53.—*Guy's Hospital Museum*, 1028[50]. Encephaloid tumours excavating the bodies of the dorsal vertebræ; *a'*, the cavity of a tumour; *a*, cavity in which a tumour is seen.

manifestly a much more dangerous form of disease than those states of wasting of the bones which take place in scrofulous ulcerations of their texture, such as are presented in the common forms of caries. It would be foreign to the object of the author of these pages to enter upon the investigation of the pathology of cancerous diseases of the body, and the attention of the reader will therefore be now directed to another form of disease affecting the bones and soft parts, and distorting the body,—namely, that which by Müller is termed *enchondroma*. The structure of enchondromatous, or cartilaginous enlargement and tumours of the bones, was very imperfectly understood by surgeons prior to the investigations of Müller. He remarks that a great variety of pathological structures, such as tubercle and fibro-tendinous enlargements, have been included under the term *chondroides*, but that sarcoma chondroides ought to be restricted to tumours identical in structure and chemical properties with cartilage. He applies the names *enchondroma* or *chondroma* to that true chondroid growth, of which the following is a general description:—"Enchondroma is a fungoid growth, proceeding from bones or soft parts; as, for instance, from the glands, and is curable by amputation. It forms a spheroidal, not a lobulated tumour. When it appears in the soft parts, it is furnished with a thin covering, resembling cellular tissue; in the bones, where its occurrence is more frequent, it retains the periosteum as its investing membrane. This disease presents itself as a soft ex-

pansion of bone, developed either within its interior, or more rarely from its periphery. In the former case, it is not only covered by the periosteum, but also by the bone itself, which is sometimes expanded to an extreme thinness. In some cases, the bony shell is not entire, and there remain only a few thin isolated bony laminæ on the surface of the tumour; the articular surfaces of the bones are either little altered, or not at all affected: anchylosis rarely takes place. The parenchyma of the mass, when divided, presents two constituents, which may be distinguished from each other by the naked eye, the one being of a fibro-membraneous substance; the other, a grey, pellucid structure, resembling cartilage, or very firm jelly. The fibro-membraneous part forms cells equal to or exceeding the size of a pea; and the larger cells contain smaller ones, in which the grey substance is enclosed; which differs from cartilage in being softer, and more nearly resembling the soft hyaloid cartilage of cartilaginous fishes, in some instances not being firmer than very firm jelly."—Notwithstanding the similarity of this hyaloid mass, when seen by the naked eye, and under the microscope, to cartilage, the fibro-membraneous capsules or cells which usually intersect the whole of the tumour are sufficient, according to Müller, to distinguish its texture from true cartilage. The development of these growths appears to take place very slowly, and without producing any pain; and, after progressing during a number of years, they become an open sore.—"Although enchondroma,

if left to itself, will burst in the course of years, and may then occasion death, by the local disorganization and loss of fluids to which it gives rise, yet the disease is curable by amputation." It appears that very insufficient attention has been paid to the constitutional derangements coincident with these morbid products. Many of these cases seem to have arisen immediately from blows; but it is very manifest that something else, that is, some specific state of the system, is necessary to bring about the peculiar formations under consideration, inasmuch as we know that in one person a blow will give rise to mere inflammation of the bones; in a second, to caries, &c.; so that the effects of the same kind of extraneous violence are variable, and dependent on the peculiar state of the person thus injured. It appears that the bones of the hand and wrist are most liable to this species of deformity. Müller states that five-sixths of the cases of enchondroma have occurred in the metacarpal bones and in the fingers, as may be seen in figs. 54 and 55. The different forms which enchondromatous tumours present vary according to the structure in which the disease is seated. The differences which these present have already been detailed by Müller, to whose labours we are indebted for the greater part of the knowledge we possess on this subject. He considers that the structure of enchondroma resembles more nearly the state of cartilage in the embryo, than in the adult; and that in most cases, the cells with nuclei only are seen, secondary cells being more rarely observed.

In a few cases, a clear substance may be distinguished

Fig. 54.

Fig. 54.—*Hunterian Museum*, No. 775. Description in Catalogue: "Fingers, with the heads of the metacarpal bones. They are the seats of several cartilaginous tumours. Two or three of such tumours are connected with the ends of the metacarpal bones; but there are two on the phalanges of the fore-finger, three or four on the third, and one is contained within the first phalanx of the little finger. All the tumours are globular, or approach that form; they are from one half of an inch to an inch and a half in diameter, nearly smooth on their surfaces, and covered each by a thin layer of cellular tissue. A section of one on the fore-finger shows that it is composed of true cartilage, like that of the fœtal skeleton, but not so uniform in texture. The section of

the little finger shows a similar tumour in the medullary tissue of the first phalanx, and the commenced expansion of the surrounding wall, and it is most probable that some of those tumours which present a more distinct swelling than this does, have likewise originated within the phalanges, and in their growth have either expanded or burst through their walls." This tumour had been growing eleven years. The patient was a girl, sixteen years and a half old, who died of consumption.—*See* "Description of Microscopic Examination, Fig. 57."

Fig. 55.

FIG. 55.—*Hunterian Museum*, No. 772. Description in Catalogue: "A finger, with a tumour growing from the palmar surface of its first phalanx. The tumour is nearly globular, about an inch and a half in diameter, and composed of a pale, firm, semi-transparent, and slightly vascular cartilage. It appears to be connected only with the periosteum of the phalanx. In its growth it has pushed aside the flexor tendons and their sheath."—*From Mr. Liston's Collection.*

between the cells, and occasionally, bundles of fibres. The size of the cells exceeds several times that of the red particles of the human blood, the nuclei of which have a diameter of from $0.^{in.}00032$ to $0.^{in.}00042$, are sometimes roundish, at others, irregu-

larly ovate, as in Figs. 56 and 57 : corpuscles are here and there seen radiating from a common centre, with spiculated appendages, which are often of considerable length, as in Fig. 58. When a portion of the structure of enchondroma of the bones was boiled for ten or eighteen hours, Müller found it yielded, on cooling, a peculiar form of jelly, to which he has given the name of *chondrine*, differing from ordinary jelly or *colla*, but identical with that found in most of the permanent cartilages. This substance possesses properties chemically different from that of ordinary gelatine ; but for the analysis of this product, the reader is referred to Müller's own work. He considers the development of enchondroma to be precisely similar to that of cartilage, the chief difference between the natural and morbid products consisting in the persistence, in the latter, of that cellular structure which cartilage presents in the embryo. He farther remarks, that—" in

Fig. 56.

Separate cells, with germinal cells; nuclei magnified 450 diameters, from an enchondroma of the parotid glands. — *From Müller's Work on Cancer, by Charles West, M.D.*

Fig. 57.

Nucleated cells from enchondroma of the hand.—*Müller.*

Fig. 58.

Radiated corpuscles magnified 225 diameters, drawn from a section of the tumour in Fig. 54. The author is informed by Mr. Quekett, that none of the cells, such as those in Figs. 56 and 57, could be observed in this section of the tumour.

the healthy primitive formation of cartilage, the vital principle controls the monad existence of the cells, and sets to it bounds which it cannot pass."—In process of time, the walls of the cells thicken, and an interstitial indistinctly fibrous mass is formed of cartilage, betwixt the cavities of the germinal cells. In enchondroma, on the contrary, the *sunken vitality* of the part in which the diseased growth is developed, seems to set no such limits; but the growth proceeds, slowly increasing to a larger and larger size. Usually, the walls of the cells do not thicken; the formative process cannot raise itself above that form of cartilage which first exists in the embryo, but continues, without ceasing, to reproduce this embryonic structure." Such are the views of one of the most justly celebrated physiologists now living; but like nearly all, if not all, pathologists, he limits his inquiries to certain points only in the investigation, and does not embrace the question of the whole of the perturbations in the system by which the morbid state is produced, and by which means only the problem in question can be satisfactorily solved. But the difficulties that stand in the way of this solution

have already been mentioned in Chap. IX., every step made in the knowledge of the chemistry and dynamics of the system, tending to furnish additional data, which are necessary to solve the more general questions presented to us in physiological pathology. What is wanting in the works on morbid anatomy, is a more accurate description of *all* the phenomena which the system presents during the progress of the disease, and it will always be an unfruitful task merely to delineate the minute structures of morbid products, without a correct knowledge of those peculiar conditions of the system under which they were produced. Müller ascribes the formation of enchondroma to the depressed vitality of the part, but he does not say to what cause we are to ascribe this state, or why this state should affect the osseous system with enchondroma in one individual, and the soft parts in another. But these changes surely cannot go on in one part of the system without some corresponding changes, either concealed or apparent, in other parts of the system—at least, to suppose otherwise would be contrary to experience. The whole of the conditions must be taken into account, in order to bring to a satisfactory result the resolution of each problem; and this principle, although lamentably neglected by pathologists, applies to physiology and pathology, as well as to every other branch of science. As enchondromatous tumours do not, like carcinoma, reappear after their extirpation, their surgical treatment is much more satisfactory. This disease often produces considerable deformity of the part in which it is seated.

There are morbid preparations of these tumours in the Hunterian, St. Bartholomew's, and Guy's Hospital museums, the study of which will prevent the surgeon's mistaking them for those malignant tumours which, after extirpation, reappear either in the same or some other portions of the body.

CHAPTER XI.

Rickets: Inquiry into its causes.—Schelling's definition of organization.—Guérin's division of the different stages of rickets; ages at which the disease invades the system; proportion of males to females numerically considered; length of the period of incubation; symptoms of incubation.—Effects of rickets on the structure of the bones.—Second stage of the disease; its effects; the whole skeleton liable to be affected; swelling of the articulations; loss of length of bones; theories of Guérin and of Mr. A. Shaw.—Third stage: Views of Wilson and Stanley; effects on the skull.—Topographical remarks; effects of deficient supply of physical agents.—Mollities ossium a distinct disease.—Sketch of the constitutional treatment of rickets.

When we inquire into the causes which produce the disproportionate growth of the bones, which is one of the characteristics of rickets, we are led to the consideration of the laws of that force by which all the vital functions are governed, and the form of organized tissues is determined. The peculiar and essential nature of the vital forces of animals is veiled from our view, as well as that of the forces concerned in the great natural phenomena of light, heat, electricity, and gravitation, to which the vital force seems to stand in correlation. But, although we do not, and most probably never shall know what the essential nature of any of the forces above mentioned really is, we are at

least enabled to observe the phenomena to which they give rise, and to ascertain the laws of their action, when the phenomena themselves are sufficiently numerous to apply to them the process of inductive reasoning. In tracing the cause of rickets, the first step will be a physico-pathological inquiry into the development of animal organs. According to Schelling, "The peculiar character of organization is, that the matter is only an accident of the thing itself, and that the organization consists of form alone. But this form, by its very opposition to matter, ceases to be independent of it, and is only in idea separable. In organization, therefore, substance and accident, matter and form, are completely identical." Dr. Whewell has defined organic life to be "a constant form of circulating matter, in which the matter and the form determine each other by peculiar laws, that is, by vital forces." It is further supposed by him, that the vital forces by which these changes are effected may be distinguished from chemical and mechanical forces, inasmuch as the latter tend continually to produce a final condition, after which there is no further cause for change. Mechanical forces tend to produce equilibrium; chemical forces tend to produce composition, or decomposition; and this point once reached, the matter in which these forces reside is altogether quiescent. But an organic body tends to constant motion, and the highest activity of organic forces shows itself in continuous change. Again, in mechanical and chemical forces, the force of any aggregate is the sum of the forces of all the parts: the sum of the forces corresponds to the sum of

the matter. But in organic bodies the amount of effect does not depend on the matter, but on the form: the particles lose their separate energy, in order to share in that of the system; they are not added, they are assimilated. These views, if admitted to be correct, will form a basis upon which to found an examination of the origin of the disproportionate growth in rickets, and may at some future period lead to the solution of the question, whether the vital forces themselves, or the materials on which they act, are in fault.

M. Guérin has divided the whole term of rickets into three periods: the first is the stage of incubation; the second the stage of deformation; and the third the stage of transition of the organs and functions to a healthy condition. This order will be observed in the following remarks. It must be borne in mind that this complaint is one peculiar to infancy, and therefore affecting the development of the system. Some few cases occur of persons born with disproportionate development of the bones; but the cases in which the disease has commenced after puberty are very rare. Out of 346 cases observed by M. Guérin, there had their origin—

Before birth . . .	3 cases.
In the first year . . .	98
,, second ,, . . .	176 ,,
,, third ,, . . .	35 ,,
,, fourth ,, . . .	19 ,,
,, fifth ,, . . .	10 ,,
,, sixth ,, . . .	5 ,,
	346

Of these, 148 were males, and 198 females. From these statistical reports, we see that the number of cases happening in the first and second years very greatly exceeds that of other periods of life, and that in the subsequent years the numbers diminish very rapidly. The predominance of female cases over those of males may be owing to the greater delicacy of female constitution.

According to M. Guérin, the time occupied in the incubation of rickets is about six months, during which a marked train of deranged actions manifests itself. Many of these actions are common to other diseases; but some are peculiar, and determine the specific characters of the complaint. The attendance of a medical practitioner is often dispensed with by parents in the earliest stage of the disorder; and it is therefore often difficult to give specific details of the state of the system at the commencement of the malady.

When the general health begins to exhibit an appearance plainly indicating that some morbid changes of the system are taking place, the most ordinary symptoms are, gastro-intestinal irritation, accompanied with diarrhœa, enlarged abdomen, nocturnal sweats, mental depression, irritability of temper, weakness and emaciation of the muscular system, low febrile irritation, swellings of the joints of the carpus and extremities generally; the urine is loaded with earthy phosphates; the bones, soft, pliable, and retarded in their growth, are swollen, and liable to curvature

under the weight of the body, or even under the natural action of the muscles; the countenance is pale, the face attenuated, giving the appearance of increased age; the eyelids are unusually wide open; the eyes brilliant, and with a lively expression; the nostrils dilated, and the lips kept apart; the skin is generally pale, and in some parts of a violet hue; the respiratory and circulating movements are accelerated; the appetite is feeble, and the digestion difficult.

During the period of the incubation of this disease all the bones of the skeleton are more or less affected; they not only become soft and pliable, but their chemical and mechanical structure also undergoes a change. The chemical change has been mentioned in Chap. I. The several effects of this alteration in the structure of the bones have thus been described by Boyer:—

"They are lighter than natural, and of a red-brown colour; they are penetrated by many enlarged blood-vessels, being porous, soft, spongy, and compressible; they are moistened by a kind of sanies, which may be pressed out of their texture as out of a sponge or tanned leather; the walls of the medullary cylinder of the large bones of the extremities are thin, while the bones of the skull are considerably increased in thickness, and become spongy and reticular. All the affected bones, especially the long ones, acquire a remarkable suppleness; but if they are bent beyond a certain point, they break, &c. Instead of being filled

with medulla, the medullary cavity of the long bones contains only a reddish serum, totally devoid of the fat, oily nature of the natural secretion."*

On comparing, under the microscope, the normal with the morbid state of the bones, in rickets, the Haversian canals are found in the latter much enlarged, owing to the absorption of the lamellated structure forming their walls. There is also a deposition of fatty matter.

Under the influence of these morbid actions, after the lapse of some months, the second stage, or that of deformation, commences. In this second stage, the effects of the ravages of the disorder become apparent in the curvature and retarded growth of the bones. The bones exhibit evidences of distortion, first in the tibia and fibula, then in the femur; and the deformity, proceeding from below upwards, invades in succession other portions of the skeleton, until the whcle is involved in the complaint. According to M. Guérin, a considerable period (from one to three years) elapses between the curving of the lower extremities and that of the spine; and he likewise states, that the amount of curvature is connected with the order in which it is developed, diminishing in degree from below upwards. In 496 cases recorded by M. Guérin, there were only eleven in which curvature of the bones did not take place, although the general symptoms, with swelling of the articulations, were present; in all the rest there

* Traité des Maladies Chir., tome iii. p. 619.

was deformity of the inferior extremities, with more or less swelling of the wrist. Amongst these 485 cases, there were deformed,—

In the superior extremity . . .	14
,, vertebral column . . .	48
,, thorax	59
,, head	17

From this Table it appears, that curvature of the spine happens in one case out of ten; that the proportion of cases in which the thorax is affected is larger, while the deformity of the head and superior extremities is much less frequent. Swelling of the articulations is one of the most constant symptoms observed in this terrible malady. Of forty-two well-marked cases, Guérin found swelling in the articulations in forty-one. The retarded development of the bones takes place in their lengths. Their actual dimensions have been measured by Guérin and by Mr. Alexander Shaw: the former compared the lengths of the bones of twelve persons in health with those of twelve cases of diseased subjects, and the mean results are stated in the following table:—

Bones.	Rickets.		Normal.		Differences.	
Fibula	9*in.*	8*l.*	13*in.*	5*l.*	3*in.*	9*l.*
Tibia	10	1	13	6	3	5
Femur	10	11	14	0	3	1
Radius	6	8	8	4	1	8
Ulna	7	6	9	3	1	9
Humerus . . .	8	11	10	6	1	7
Clavicles . . .	5	2	5	8	0	6
Sternum . . .	5	0	5	5	0	5
Vertebral column	20	11	22	0	1	1
Three diameters of the pelvis	11	9	13	6	1	9

These bones, taken in the order of the table, decrease in the proportion of 28, 25, 22, 20, 19, 15, 9, 8, 5, per cent., and the three diameters of the pelvis 17 per cent. Such is the relation of the reduction of the bones, taken from below upwards. Mr. Shaw computes the amount of retardation in the growth of the upper, compared with that of the lower extremities, as 3 to 13. Hence there is a very great difference between the results of the measurements of Messrs. Guérin and Shaw; but, at all events, they both tend to show the greater effect of the disease in retarding the growth of the lower extremities.

In the last stage of the disorder, the functions of the body are slowly restored to a normal state of action. The first steps towards improvement are observed in a slight remission of some of the symptoms that had continued during the primary and secondary stages of the disorder. During this progress towards a more healthy condition of the system, the diseased formation of the bones is not only arrested, but a deposition of healthy osseous materials also takes place. Wilson observed that, when the bones begin to recover from the disease, the deposition of osseous matter is most actively carried on in those portions of bone where it is most wanted,—that is, "on the inner or concave surface of the curve;" and Mr. Stanley not only confirms Wilson's remarks, but further states that the thickness of the bone at the part most curved bears an exact ratio to the degree of curvature that the bone has undergone. The deposition of ossific matter is not always, however,

adjusted to the mechanical conditions of the parts of the body as means to ends; on the contrary, the bones of the skull are often thickened far beyond their normal state, and beyond what is necessary for the protection and support of the brain under ordinary circumstances. It is stated that Sir Charles Bell had in his museum rickety subjects, in which the parietal bones were seven-eighths of an inch thick at their central parts. When the patient has recovered a healthy tone of the system, and the bones have resumed their natural standard of hardness, density, and elasticity, and their other physical conditions, except those of position and of form, the alteration of these latter produces a distortion, which usually continues during the remainder of the life of the individual.

It has been imagined that rickets is a disease peculiar to England; but the statistics of French writers, and the number of squalid, rickety forms seen running about in the streets of Amsterdam, show that the populations of other countries do not entirely escape this fearful malady. If we search for the causes by which the disease is generated, we find that it most frequently occurs among persons living in low, dark, damp, filthy cellars, and ill-ventilated and over-crowded dwellings, such as may be found in many parts of this metropolis, where they are not only ill-fed and ill-clothed, but are also denied the enjoyment of a due supply of the great physical agents of life,—namely, light, heat, pure air, and water. When a great number of persons live in the circumstances just mentioned, it cannot excite

surprise that their constitutions should be subject to various derangements, and amongst these to that of rickets. Cases of this kind, however, do occur in the families of the opulent, who are exempt from the ordinary disadvantages just described; and hence, a large field of inquiry is laid open. What are the exact external conditions, and internal predispositions, which are necessary to engender this specific form of disease, is a problem yet to be solved, in order to do which effectually we must acquire more knowledge than has hitherto been obtained.

Several authors have classed mollities ossium with rickets; but there are many phenomena peculiar to the former; such as the later period of life at which the attack commences, the urgency of the symptoms, and the pathological and physical conditions of the bones, which do not become pliable and bend, as in rickets, but break under a slight force. Moreover, in mollities ossium, the microscope shows that the Haversian canals are much more enlarged than they are observed to be in rickety subjects. The morbid conditions of the bones in mollities have been minutely examined by Messrs. Dalrymple, S. Solly, Paget, and others, to whose excellent observations the reader is referred, this subject being introduced here merely to give the author an opportunity of expressing his dissent from the opinion that the pathological conditions of the system in rickets and in mollities ossium are identical. Fortunately, the latter is a disease of comparatively rare

occurrence, and therefore of less interest, at least in a general point of view.

In the treatment of rickets, a course of constitutional, as well as of mechanical remedies is required. With respect to the former, although it may be impossible to trace the disease to its source, and to pronounce whether it originated in a defective action of the vital forces, or in the defective quality or quantity of the materials acted upon by these forces; yet the symptoms themselves being well defined, there is no reason why the practitioner should not do much to alleviate, where he cannot entirely remove them. In this, as in most other diseases, it is of great importance to place the patient under the most favourable circumstances with respect to external influences; that is, if possible, to give him the full benefit of living in a healthy situation, with a free circulation of air. The diet must also be generous, and adapted to the digestive power of the patients, and their peculiar idiosyncrasies. Many have at times a loathing of solid animal food, and will partake only of milk and farinaceous substances. When the mesenteric glands are enlarged, the administration of mercury and chalk, with rhubarb, in small doses, is found useful. In order to restore the power of the assimilating and absorbing system, the author has found the preparations of iron combined with iodine very beneficial. When diarrhœa is frequent, it should be arrested in the early stage by mild astringents; and, when nervous irritation and want of sleep are urgent,

sedatives judiciously administered will be desirable. As it would, however, be impossible to propose any treatment, except in outline, that might be found generally applicable, it is useless to dwell on the effects of particular remedies in these affections; they must be selected in each case according to the pathological condition of the patient.

CHAPTER XII.

The human frame, considered as a complex machine, necessary to be studied in the treatment of Deformities; the influence of the muscular system much neglected in the treatment of Deformities.—The theory of normal and abnormal movements of the body has not kept pace with that of Statics and Dynamics.—Empiricism; the result.—Stretching system in the horizontal position examined.—Ambrose Paré's method of treating Spinal Deformities; Apparatus employed in the convent of Sacré Cœur; Apparatus used by Maisonabe.—Stretching the body vertically; plan of Mr. Coles; effects of stretching examined.—Failure of an enormous force used to tear the limbs asunder.—Opinion of Sir B. Brodie on the stretching system.—Propping use of Corsets or Stays; effects of Stays examined; their debilitating effects on the muscular system; their effects on respiration, circulation, and digestion; their effects on the human figure; their use dependent on ignorance and vanity.—Neglect of family medical attendants with regard to the physical education of children.—Stays both distort and correct distortions; this apparent paradox examined.—Do distortions of the spine arise from its being overloaded?—This question answered.—Cases in which a recumbent position of the body is requisite.—Mechanism adapted to meet these cases very briefly examined.—Triple inclined planes; prone planes; Dr. Arnott's hydrostatic bed; spring bed, &c.

In some of the preceding pages an outline of the mechanical causes of distortion has been given, from which it is obvious that the treatment of such cases

should be founded on mechanical principles, the application of which now remains to be explained. Whoever undertakes to cure distortions should be perfectly conversant, not only with the structure of the human frame, but also with the bearing of each part of it on every other; for it is not enough to bring in aid the extraneous force of an instrument to remedy a distortion, however well qualified it may be to correct the particular evil, without having the certainty that its use will give rise to no other derangement of the system, and this can only be known from a careful investigation into its relative effects on the several parts of the body considered as a complicated machine—a problem which generally does not admit of an easy solution.

It is remarkable, considering the attention that has been paid to the muscular powers which nature has bestowed on the human body, how little these powers have been employed in attempts to correct distortions. Hence we have a multitude of machines invented for the purpose of doing what they have never accomplished, in cases in which the only mechanism needed might have been found in the body itself; while in others, in which extraneous aid was required, that which was employed has often been at variance with physiological and mechanical principles; so that we find that in cases in which the causes of distortion are very dissimilar, the mechanism adopted to relieve them has been almost, if not entirely, the same. It cannot be denied that while statics and dynamics have engaged the attention of the greatest mathematicians

since the time of Aristotle, and a great number of problems in those branches of science have been solved, very few surgeons have sufficiently studied them, and the medical profession has consequently been totally incompetent to grapple with the theory of the normal and abnormal attitudes and movements of the human body. Under these circumstances, we need not be surprised that mechanism constructed in imitation of the rack, gallows, and sundry other combinations of mechanical powers, have been resorted to and applied to cure distortions, and are not only recommended, but actually used to this day, both in this country and abroad.

The various kinds of machinery just mentioned may be classed under three heads—namely, 1st, those designed to stretch the body either in a horizontal or vertical position; 2nd, those which tend to prop the body and limbs; 3rd, those which have for their object the reclining the body either obliquely or horizontally, in prone and supine positions. It will be convenient to discuss in this order the value, both real and assumed, of these several plans of treatment, also taking a glance at the machinery employed in stretching.

The practice of stretching the trunk in curvatures of the spine has been more or less adopted in Germany, France, and England, and is still in constant use. An idea has prevailed, that when the spinous processes of any of the vertebræ appeared prominent in the mesial plane of the back, the bones had glided backwards, and had become partially dislocated. I have,

however, demonstrated the falsehood of this hypothesis in Chap. IX. It appears that Ambrose Paré considered distortions of the spine as being dependent on the dislocation of one or more of the vertebræ. He says,—"The rack-bones of the back may be dislocated inwards, outwards, to the right side, or to the left. We know that they are dislocated inwards when they leave a depressed cavity in the spine, outwardly when they make a hunch on the back; and we know they are luxated to the right or left side when they obliquely bunch forth to this or that side." In order to replace the vertebræ, he recommends that the patient be laid on a table, with his face downwards; he is then to be bound by passing towels tightly under the arms and around the thighs, the ends being left free, so as to be held by two assistants, one placed at the head, the other at the feet; the assistants pulling the body in opposite directions, as seen in fig. 59. The surgeon is then directed to force the dislocated vertebræ into their position by the hands, and the parts are to be secured by splints or plates of lead made on purpose, lest the vertebræ should fall out again. The assistants are directed to extend the spine with as much force as possible, but without violence; for he observes, that unless such extension be made, no restitution of the vertebræ can be hoped for, by reason of the processes and cavities, whereby, for the faster knitting, they mutually receive each other. Such were the views and the methods employed by Paré to restore the figure of the back, under the supposition that curva-

tures of the spine depend on the dislocation of some of the vertebræ.

Fig. 59.

Orthopædic surgery does not appear to have advanced in Paris since the time of Paré. The late Mr. John Shaw has described and illustrated the -ious plans pursued when he was in Paris about the

year 1825, from which I have selected the method of extending the body then employed in the convent of Sacré Cœur, and by Dr. Maisonabe.

The object of this apparatus is to keep the body stretched by the help of powerful springs, made on the same principle as those used to try the strength of horses, which are drawn into action by means of a winch, or wheel, placed at the lower end of the bed: the communication between the body and the springs is made by the application of the casque on the head and the girdle round the pelvis.

"The bed, or mattrass, on which the body is laid," says Mr. J. Shaw, "is stuffed, and is so convex that the spine, or only the middle part of the back, is supported; it is of such a shape that it would be impossible to remain on it if the body were not fixed. Several springs (not represented in the figure) are

Plan of the apparatus used at the Sacré Cœur.

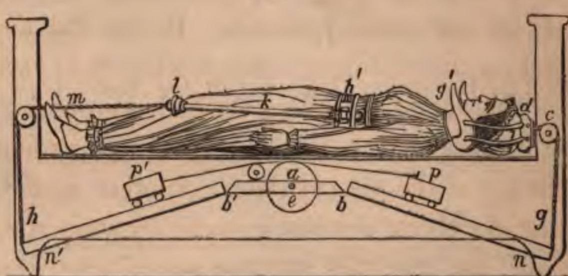
Fig. 60.

attached to the sides of the bed. Some project in a direction nearly horizontal above the mattrass; so that the sides of the patient, instead of resting on the bed, are supported by several points. The object is to push in the projecting parts, while other springs pass

over the body and press upon the ribs in front." The patient is retained in this apparatus, and the body kept stretched during the night and greater part of the day, and when released he is to undergo another plan of stretching by the aid of an apparatus acting vertically, or is put into a strong corset or cuirass, or mounted on long crutches, which permit the toes only to reach the ground; and at meals the body is supported by crutches attached to the chair. The system pursued by Dr. Maisonabe, according to Mr. J. Shaw, is nearly the same as that just described; but the mechanism of his bed is different, and he trusts almost entirely to extension.

The apparatus of Dr. Maisonabe.

Fig. 61.



Description of figure from Mr. J. Shaw.—The machinery, when in use, is concealed by a board, leaving only a hole communicating with the axle *e*; *a* represents a piece of wood passing from one side of the bed to the other, *b n*, *b' n'*, two boards, twenty-eight inches long, four broad, attached by hinges at the ends *b b'*, and to the cords, *g h*, at the other; *p p'* are weights of twenty-five or thirty pounds, mounted on wheels, and running in grooves, on the boards *b n*, *b' n'*; the weights are connected

with the wheel *e*, by cords; by means of a key, acting on the wheel *e*, the position of the weights may be varied on the levers *b n*, *b′ n′*, by which their power is increased or diminished; the body is connected with the cords *h g*, by means of the collar *g*,′ round the neck, and the band *h*,′ round the hips. When the patient is placed in position, and connected with the apparatus, the operator then stands behind the upper end of the bed, and taking hold of the patient's head, extends the vertebræ by pressing the foot on the lever *n*; and by turning the wheel, arranges the position of the weights.

By means of this apparatus he is of opinion that he can regulate the degree of power employed more readily than can be done by the instruments used at Sacré Cœur.

Mr. Shaw has also described and illustrated several other plans adopted by Messrs. Lafond, Duval, and others, having for their object the stretching or bending the body in horizontal positions. Besides the means employed on the continent, other machinery of various kinds and power for extending the body in a horizontal position has been extensively employed in this country, and is in use at the present time. Another system of extending the body consists in vertically supporting it in the air, and for this purpose several contrivances have been had recourse to, one or two of which may be adverted to by way of illustration. In a work by Mr. Coles, the following plan is recommended: "When the curve is situated high up in the vertebral column, or in the neck, a useful mode of extension is accomplishable by means of a head-swing. A padded strap passes under the chin, and round the back of

the head, the ends meeting just above the temples; from these a strap on each side passes about six inches above the head, where they unite, and terminate in a hook; this is fastened, when required to be used, over the loop of a double cord, which passes upwards to a beam, or doorway, and over two pulleys fixed in the wood work; these cords then again descend, and terminate in small handles just within the extended arms of the patient, who grasps them, and by pulling downwards raises himself off the ground by the head and arms, thus combining both active and passive extension in one operation!" An instrument well known by the name of the Hinkley Collar has been already figured, and its merits examined in Mr. Shaw's work on the distortion of the spine. This is another apparatus adapted for extension. It would be easy, were it necessary, to find numerous other plans having the same object—namely, that of stretching the body vertically, but those already referred to will be sufficient. It is not the principal object of the author of these pages to direct especial attention to the details of the particular means employed in stretching the body, but to the ends aimed at by the surgeons who employed them; not to *what* machinery is used, but *why* it is used; not to how the body is stretched, but why and with what results. If an examination be made into the effects of extending the body in the axis of its length with the view of correcting distortions of the spine, it will not be very difficult to demonstrate, in the first place, that it can never effect the object

sought; and secondly, that the practice is not merely insufficient, but absolutely injurious. Now with regard to the effect of what is termed stretching the spine in cases of lateral distortion, it has been seen in Chap. II. that, in its natural figure, the spine presents three curves, of which the one designed to give space for the great organs of respiration, circulation, and digestion, is by far the largest. Any strong force acting in the longitudinal axis of the body tends to diminish the natural curve of the spine, and deprives the latter of its rhythmical action during the respiratory and expiratory movements, alters the action of the ribs and muscular system, and the play of the pulmonic and abdominal viscera, so that the tendency of the stretching is to destroy the natural curves of the spine, in the endeavour to correct those which are abnormal. A general notion prevails, that the curvatures to which this plan of treatment is applicable have been primarily induced either by the weight of the superincumbent parts or by the abnormal contractions of the muscles of the back, and that to counteract these effects extension is necessary.

Now it will hereafter be shown, that with the exception of those cases of curvatures in the mesial plane occasioned by disease of the bodies of the vertebræ, the ordinary cases of curvature originate neither in the action of the superincumbent weight, nor in the unequal contraction of corresponding muscles; and if this be so, since extension cannot effect a cure when the bones of the spine have assumed a wedge-like

shape, while if they still retain their normal figure other more simple remedies will be found efficacious, it is clear that the extending principle must be altogether useless, to say nothing of the confinement, torment, and loss of health, occasioned by this plan of treatment. Practitioners who pursue the extension system are probably little aware of the great amount of force necessary to accomplish its end, and the injurious consequences of force when applied to the soft parts. Dr. Hodgkin mentions the case of a man who, during the reign of Louis XIV., was condemned, in consequence of some religious opinions he had uttered, to be torn to pieces by horses. "One horse was attached to each extremity, but the force of both horses was insufficient to effect the purpose designed. Upon perceiving this, the executioner cut the muscles through before the limbs of the wretched victim could be torn from the body." This gives some idea of the muscular force in resisting extension produced by forces external to the body. Sir Benjamin Brodie observes that no machinery ought ever to be employed for the purpose of elongating the spine and correcting deformity. There are, however, practitioners in the present day, who make use of powerful machines, capable of overcoming the anchylosed union of the diseased parts of the vertebral column; and it is reported that life has been sometimes sacrificed in the attempt.

Propping and Supporting systems.—Perhaps no apparatus has been so extensively applied to the framework of the human figure, especially in the female sex,

and has produced such mischievous results, as corsets or stays; and notwithstanding all that has been urged against their use by medical men, there is not one woman out of a thousand who is not daily encased in one of these machines.

An idea must surely prevail, that from an early period, the human body is not a self-supporting machine, and is therefore in this respect inferior to the lower animals; whereas, in truth, the greater the freedom of muscular movement, the greater is the normal strength and power of the muscles to keep the body erect. But let us inquire into the actual effect of stays, especially when applied to growing persons between the periods of youth and adolesence; and let us take for example a young girl of from four to fourteen years of age. Up to the first period the parents usually allow the muscles to perform their natural office of controlling the attitudes, and of preserving the equilibrium of the body about its centre of gravity. This power is only attained during the period of infancy after long practice, attended with numerous falls and bruises. When the child has acquired a perfect control over the various attitudes which the body commonly assumes in youth, when the muscles have been accustomed to freedom of motion, and when the erect position is maintained with perfect ease, then the parents usually encase the body in some kind of corset, which restrains the movements of the back within narrower limits than those to which it had been accustomed; the muscles are at the same time curtailed of their

natural action, and lose a portion of their power, becoming less able to support the trunk steadily. In a short time after the application of the stays, the wearer feels unable to maintain the erect position comfortably without them; and after the lapse of a still greater period, by habitual use, these unnatural appendages to the human figure become apparently, though not really, as necessary to the individual as is the natural carapax to the tortoise. The injurious effects of corsets, however, are not confined to their debilitating influence on those muscles which serve to keep the trunk erect; they extend to several other very important functions of the body. It is well known that the framework of the thorax is composed of an assemblage of bones and cartilages, which are articulated to each other in such a manner as to allow, during the respiratory processes, of very peculiar movements essential to a healthy state of the body. One of these movements—namely, that of inspiration—increases the horizontal section of the thorax; but since stays are usually composed of unyielding materials, the full expansion of the chest, and its normal and automatic movements, are impeded. When the stays are laced tightly round the body, under the erroneous idea of improving the figure, the natural areas of the thorax and abdomen are diminished, the viscera displaced, and the great vital functions of respiration, circulation, and digestion deranged. In some excellent papers printed in the Philosophical Transactions, and in the Transactions of the Provincial Medical Association, Dr.

Sibson has described and figured the positions of the ribs and viscera during the various changes in the respiratory processes. An analysis of his views would be too long for insertion here; but sufficient is generally known and admitted of the normal movements of the thorax and abdomen, to prove the injurious tendency of confining the body in stays.

Soemmering has figured and described the injurious effects of stays, and compared the outlines of the statue of the Venus de Medici with that of a stay-laced young woman of the modern school, and it need not be added how greatly to the disadvantage of the latter. In spite of all that has been said against the use of stays by medical writers of every grade, almost every young female is provided with an apparatus of this kind at that period of life when the vital functions of the body are in the stage of vigorous development. It may naturally be asked why this practice is kept up. The solution of this question is to be found in the ignorance and vanity of the parents, and the neglect of the family medical practitioner.

The hypothesis which prevails amongst mothers seems to be, that the more nearly the body is separated into two portions at the waist, the greater is the approach to perfection of figure; and this mischievous idea is extensively brought to bear upon their daughters, not only at the expense of their normal figure and the real outlines of beauty, but to the permanent loss of health and strength.

With respect to the physical education of young

people, I do not find the professional advisers of families troubling themselves or their patients on the subject. If the mother of a numerous family is asked what her medical attendant recommends respecting the use of stays and gymnastic exercises for her children, the answer in nine hundred and ninety-nine cases out of a thousand will probably be, that the point has never been discussed; and it is only when the first stage of some kind of deformity becomes apparent that any attention is directed to the subject.

If corsets are so detrimental to the figure and health of young persons as all experience proves them to be, and if they lead to debility and deformity of the trunk, how is it that they are introduced to correct the evils they produce? Is there really existing in this case an illustration of Hahnemann's dogma—"Similia similibus curantur?" A strict examination into this matter will dispel the illusion, and show the practice, although somewhat plausible, to be really unsound. Stays of different kinds have long been introduced with a view of supporting the spinal column, and correcting its distortions, under an impression that curvatures of the vertebral column arise either from its being unable to support the superincumbent weight, and its yielding in the same way as any other elastic column of metal or wood bends when overloaded; or from the muscles on one side of the spine acting with greater force than those on the other, and so pulling the spine into abnormal curves. It is supposed that if the trunk be encompassed with a corset which props up the

columns, and at the same time presses against or pushes in the prominent parts, both the tendency to distortion, and the distortion itself, will be removed. Accordingly, we have Hossard's lever belt, Tavernier's lever belt, with inclination busk, Amesbury's, Biggs', and a large variety of stays, all of them designed for the object just mentioned.

Another method which has been and still is extensively employed to take off the superincumbent weight from the spine, is that which is denominated the *supine* and *prone* positions of the body.

There is, without doubt, a large number of the more aggravated cases of curvatures of the spine depending on diseases of the vertebral column, which renders it indispensably necessary that the patients should be kept in a state of rest, and in a nearly horizontal position; and it becomes a subject of no little importance to determine how this is to be accomplished in a manner the least liable to objection. It is well known to every practical surgeon, that the human body cannot be kept continually in any one position without entailing effects which are not only detrimental to the general health, but which induce organic lesions of the soft parts on which the body rests. The functions of the skin are impeded by constant pressure, and all the muscles require to be occasionally brought into action. Now these general physiological conditions are opposed to the therapeutic means necessary for the cure of local disease; and the problem to be solved

is, how to give the body the greatest relief with the least injury.

Many kinds of machines have been invented, in order to meet the difficulties of the subject, among which, those most in use are the late Mr. Earle's triple-inclined plane, the prone planes, Dr. Arnott's hydrostatic bed, spring beds, &c. The advantage of the triple-inclined plane in diseases of the spine is the facility of altering the angles of flexion at the hip, knee, or ankle joints, and of varying the inclination of the trunk, whereby the pressure of the body on any points of its surface in contact with the plane is varied, without causing the body to move upon itself by much exertion; while, during the night, the inclined plane, being adjusted horizontally, gives the patient the opportunity of turning the body partially round upon either side, and relieves the back from the pressure it has sustained during the day. The triple-inclined plane is therefore a very useful machine in the hands of a skilful practitioner who has the ability to discover in what manner and in what cases it should be used; but, like many other useful inventions, when left to the discretion of those who have not studied the mechanism of the human frame, and the objects of the machine itself, it has been very much abused.

The prone plane, recommended by several orthopædic practitioners, possesses none of the advantages of the triple-inclined plane, since the prone position of the body is the only one for which the apparatus is intended. The

hydrostatic bed has the advantage of subjecting portions of the body in contact with the bed to an equal and uniform pressure, and allows a greater number of points to receive support; and the surface of the skin is therefore less liable to be abraded. It appears well adapted for cases requiring constant horizontal position; but it is necessary to place some medium between the surface of the body and the bed to allow of the transmission, or to promote the absorption of the natural excretions from the skin. The spring beds are intended to effect the same object as the hydrostatic, and are, in a great measure, a very good substitute; for besides admitting a change in the inclination of the body, they give free passage to the perspiration.

CHAPTER XIII.

The recumbent, supine, and prone positions discussed; the prone position; its effects; Mr. Liston's opinion respecting it.—Strength of the spine; erroneous opinions on the subject; not liable to fatigue.—Stooping a state of increased action.—Spine not liable to bend; it rests on a small base.—Surface of sacro-lumbar articulation altered by the disposition of the legs.—Division of lateral curvature into three stages; treatment in these several stages.—Distortions of the lower extremities; their treatment.—Use of leg-irons; their action; require to be jointed.—Propping the spine, and neglecting the legs, shown to be irrational.

A GREAT deal of discussion has arisen as to whether patients requiring a recumbent posture should be kept continually in a supine or a prone position. It has been already stated, that no person can be kept in any one posture for a long time, without detriment to the general health; and that organic lesions of the soft parts on which the body rests are thereby induced. As these are well-known facts, it becomes a matter of very serious importance to decide in what cases of distortion the recumbent posture is advisable—whether the supine or the prone position is preferable—and whether it is necessary that patients should be kept constantly in one or other of these positions. In inflammatory states of the intervertebral substance, and in caries of

the vertebræ, which always require that the parts affected should be relieved from superincumbent pressure, and kept in a state of rest, there can be no doubt that the recumbent posture is necessary. The tendency of nearly all invalids, when confined to their beds by aggravated sickness, is to lie in the supine posture; and this they do spontaneously when the disease is of such a nature as to render it indifferent to the practitioner what kind of posture the patient may be inclined for ease and convenience to choose. Whatever may be the immediate pathological cause of invalids thus assuming the supine position, the fact of their doing so shows, that it must be the most agreeable one; but although the form and structure of the posterior surface of the body render it best adapted for reclining on, this posture cannot be permanently maintained without injury to the integuments. The position is, besides, objectionable, because it prevents access to the parts which may require topical applications, such as liniments, frictions, blisters, setons, issues, leeches, &c. This objection holds good as long as the patient is not allowed to turn on his side; but as this might be done without injuriously disturbing the affected parts, the supine position could be resumed when desirable, and the patient placed on the side when necessary. The advantages of adopting a recumbent position, and occasionally changing it from the back to the side, in organic diseases of the vertebræ, has been experienced by the author in so many cases as to justify his giving to the supine the preference over the prone posture.

The result of a number of observations, without entering into details, is this—namely, that in cases of curvatures of the spine arising from disease and absorption of the bone, the distortions do not increase while the body is kept in horizontal, supine, and lateral positions; but they do increase when the body is allowed to move and be erect; and that, moreover, when patients are confined to the prone position, so far as the author's experience goes, the curve of the spine is progressive, for which there are obvious mechanical reasons. For instance, in all cases, both of diseased bone and curvature, the superincumbent pressure cannot be wholly withdrawn in any oblique position; and where the curvature is in a plane or planes intermediate between the mesial and transverse, as generally happens, the deformity may often be increased by the tendency of the unsupported curved position towards the transverse plane.

Under the prone method of treatment the patient is laid on the face on a double-inclined plane, as seen in figure 62, so that the weight of the trunk is supported on the thorax and abdomen; and, accordingly, the head must either rest on the lower jaw, or be upheld by its extensor muscles and ligaments; the play of the ribs and of the abdominal and thoracic muscles and viscera is restricted, and after a time the thorax itself is flattened, and the digestive, respiratory, and circulating functions are more or less impeded. The advantage derived from a prone position, as a set-off to these grave evils, is the facility of making topical applications. Mr.

Liston observes,—" Perhaps the prone position, about which so much has been said lately, is the most favourable, as it takes pressure off the diseased parts, and prevents the carious bodies of the bones from falling upon one another. It also assists the return of the blood from the numerous veins contained in the vertebræ and in the spinal cord."

Now if all the advantages just enumerated really existed, we should then have to consider, not only whether they counterbalanced the injuries sustained by this system, but also whether either the supine or prone position ought to be continued throughout the whole treatment of organic diseases of the vertebral column.

The case of a patient was mentioned in Chap. X. who, after having been placed on a prone plane for some time, was obliged to be moved into another position—the prone system of treatment having become intolerable.

The following case will afford another example of the effects of this plan of treatment :—

J. G——, a girl, aged eleven, was admitted in 1839 as a patient at the Northern Dispensary, and discharged in 1844. She presented the general aspect of a child in a delicate state of health. Her parents were extremely poor, and uncleanly in their habits. Her countenance was pale; eyes large and expressive; abdomen large and hard, as in mesenteric disease; digestion languid and imperfect; appetite deficient; and bowels irregular. On examination, there was found a slight lateral curvature of the spine, with

symptoms of a softened state of the bodies of the vertebræ; and the prostration of strength was so great, that standing and walking soon produced a sense of weariness. There was no pain in the region of the vertebral column, and the pressure of the hand was borne with ease throughout its whole length. She was ordered a mixture composed of iron and iodine, and reclined on a triple-inclined plane. However, great desire was expressed by one of the governors of the institution that the patient should be placed on a prone plane, and a fair trial given to that system of treatment. This having been assented to, the patient was removed from the triple-inclined to the prone plane, under the immediate superintendence of the late Dr. Verral. Previously, however, to the patient's removal from the triple plane, there was a very slight tendency in the spine to curve in the mesial plane, and symptoms of organic disease of the bodies of some of the dorsal vertebræ had just become obvious. The author then lost sight of the case during from twelve to thirteen months, the child being removed to another residence; when, being again consulted, he found the patient still lying on the prone plane, to which she had been confined night and day for nearly two years. She was labouring under extensive disease more or less involving the bodies of ten of the dorsal vertebræ; the angular curvatures had gone on increasing during the whole of the time she was on the prone system of treatment; the thorax was flattened; the heart throbbed against its walls; the functions of circulation and

respiration were impeded; and the general health was impaired.

The annexed drawing, made whilst the patient was lying on the prone plane, will give a more accurate idea of the position and the amount of deformity than could be conveyed by mere description. Since no part of the body can be subjected to continual pressure without ulceration being produced, it is clear that

Fig. 62.

whatever state of recumbency may be adopted, it ought not to be persevered in for any length of time; but relief should be afforded by changing the position, which, as we have seen, may be done without detriment.

In cases of ordinary lateral curvature arising from unequal pressure on the vertebræ and intervertebral cartilages, no good beyond that of taking off the superincumbent weight can be expected to arise from the recumbent posture; but to restore these organs to their normal condition will require something more than their being merely relieved from the general pressure, especially if the complaint has been of some standing, and the bones and cartilages have acquired an altered figure. It is from this circumstance that surgeons are disappointed, when, after having laid a patient in a reclining position for many months, nay, sometimes years, they find, to their great mortification and chagrin, that the moment the erect position is attempted to be resumed, the curvature re-appears as before : in fact, it could not be otherwise, inasmuch as distortion, arising from a certain amount of mechanical force, must be counteracted, if it ever can be counteracted, by at least some amount of force applied in an opposite direction, and this the recumbent position alone is not calculated to effect. It can only be done on the same principles of equilibrium, and of the effect of extraneous forces on the body, which have already been stated. The nature of the distortion must be clearly made out before any therapeutic agents are employed ; and it is not difficult

to form a tolerably correct diagnosis of these cases. It is manifest, from the preceding considerations, that lateral curvature of the kind above mentioned should not be treated by laying the patient for lengthened periods in the recumbent posture. In the first stages, when no abnormal change has taken place in the bones and cartilages, and a tendency is perceived in the young and delicate to assume a position prejudicial to the figure, accompanied with a sense of weariness after standing and walking, the patient should resort to a recumbent position, and lie on a firm mattrass or couch for some time every day, according to circumstances, as long as may be required; not with a view of curing the lateral curvature of the spine, but in order to rest the body, so that the patient may not be induced to assume the attitudes which produce this form of distortion when standing. When the spine is affected with caries of the bodies of the vertebræ, the recumbent posture is indispensable, and no machinery adapted to prop, push, or stretch the body that has ever been invented will be efficacious in the treatment of these cases. When the patients are laid in a recumbent posture on the first appearance of organic mischief, the amount of distortion is greatly diminished. Much depends on the care and manner in which this reclining is carried out; the more nearly the body lies in the horizontal plane the better, for important reasons. When the head-piece of a triple-inclined plane is raised to an angle scarcely sufficient to allow the patients to see horizontally, they have a constant

tendency to raise the head above the plane, by which means the bodies of the affected bones are irritated and pressed on; if, therefore, this tendency is observed, it will be necessary either to lay the patient perfectly flat, or to confine the head to the plane, according to circumstances. The nearer to a horizontal posture the trunk is laid in, the less, owing to the direction of the great dorsal curve, will be the pressure on the bodies of the dorsal vertebræ; and if the mischief is in the lumbar region, it will be necessary to adapt a support to the lumbar curve. The same may be observed when the disease affects the cervical vertebræ; indeed, a person conversant with the figure and mechanism of the spine may easily release any portion from injurious pressure, by adapting the surface of the couch to the circumstances of the case, without having recourse to the barbarous stretching machine of the English and French schools. This end may be accomplished by considering the spine as a bent lever, and causing it to rest on a point, as a fulcrum, opposite the parts requiring relief; the weight of the body itself then acts at each end of the lever, and exerts a mechanical force quite sufficient to release from pressure the parts affected with organic disease.

It is remarkable that while one class of surgeons teaches that the human spine is sixteen times as strong from being formed of three curves as it would be if straight, and that the vertebral column is consequently an organ of great strength, another class pretends that it is so weak, that in delicate persons it cannot support the weight of the superincumbent parts of the body,

and requires to be supported by extraneous mechanism. The fallacy of the former hypothesis has been already demonstrated (Chap. II.), and it is now desirableto investigate whether the latter is, or is not, more tenable. In an ordinary state of health, all experience proves that the spine is not only an organ of very great strength, but that it is little liable to bend under loads equal to, and often greater than, the whole weight of the body.

In the ordinary exercise of standing and walking, the spine is the least liable to fatigue, not only from its structure, but from its functions. When persons have undergone fatiguing exercises, in order to rest their weary limbs they usually put the body in a sitting posture, to take the weight off the lower extremities. After sitting for a limited period, the sense of fatigue passes off without resting the spine. When any delicate persons lounge, and bend their knees, and stand on one leg, it is not to relieve the spine, but to transfer the action of the muscles of the legs from the flexors to the extensors, which are of far greater power; the same effect is produced when persons stoop—the extensors of the back are thus thrown into greater action. Many suppose that the act of stooping implies weakness of the dorsal muscles, whereas they are then in a state of increased action. If the spinal column has a tendency to bend under the weight it is destined to carry, how is it that this organ does not become more commonly distorted in the plane of its natural curves? Unless, indeed, there be disease of the bones of the spine, the origin of ordinary cases of lateral curvature is rarely found in the

spine itself, but is produced by extraneous forces; for the bones, muscles, ligaments, and cartilages, are all in a state of uniform action on each side of the mesial plane of the body, and the tendency in the spine to bend must necessarily be in that plane. The vertebral column rests on a very small base compared with its height—namely, on the sacro-lumbar articulation; and whatever tends to incline the surface of that articulation, either laterally or obliquely to the horizon, must produce corresponding movements of the whole vertebral column, and thus induce curvature out of the mesial plane.

Now the direction and position of the surface of the sacro-lumbar articulation may be varied by the length and disposition of the legs: if one leg be shorter than the other, the articulation will be inclined in standing towards the side of the shorter leg; and the same thing occurs when one leg is flexed at any joint while the other is extended. The structure of the pelvis prevents any inclination of the sacrum upon itself, independently of the whole of the pelvis. The progress of lateral curvature not originating from organic disease, may be divided into three stages. The first comprehends those cases where the curvature depends upon attitude, or the presence of extraneous force, without having produced any altered figure of the vertebræ, or absorption of intervertebral cartilage. The second comprises those cases in which the curvature results from a slightly altered figure of the vertebræ and cartilages, in very young and growing persons, the bones not being yet

sufficiently hardened with their due proportion of earthy constituents, and where the curvature is produced by extraneous forces. The third embraces cases of long duration, in which the vertebræ have assumed an altered figure, and have become hardened by an increased supply of earthy constituents; the persons are of a more advanced age, and the body has acquired a position of equilibrium corresponding to the distortion of the spine. The great objects to be kept in view by those who have the management of children are, to see that none of those causes which produce ordinary lateral curvatures be suffered to act, and to attend to the physical condition of the body in the earlier stages of development.

It is from the neglect of these precautions that children fall from the primary into the secondary stages of lateral curvatures. When the vertebræ and intervertebral cartilages lose their natural figure, the body assumes a new state of equilibrium, in which the spine is curved laterally, and often twisted spirally; and if time be allowed for the vertebral bones to grow and become hard, while the body is thus distorted, the patient falls into the third stage, in which no mechanical treatment will restore the parts to their normal figure. In order to rectify lateral curvatures of the spine with the greatest certainty and least loss of time, they should be taken in hand as early as possible in the first stage, before the vertebræ change their normal figure, when a clear perception of the cause will enable any person acquainted with animal mechanism to remedy the mis-

chief; and the practitioner will be enabled to effect in a few weeks a cure for which probably years would not suffice if the disease were neglected at this time. In the treatment of the second stage, we have first to ascertain the immediate cause of the distortion, and the nature of the extraneous force acting on the spine,— whether it be in the body or external to it; and when the nature of the force is considered, whether it be constant or intermittent, avoidable or unavoidable: we can then determine the means of counteracting it; but without this previous knowledge, any attempt to restore the patient must be empirical. It is of fundamental importance to provide means that will put the body into a state of equilibrium, with the spine erect. This should be effected by putting the patient into the proper attitude, if practicable, by means of the muscles themselves.

When the cause of the curvature is external to and independent of the spine, it is quite clear that the measures to be taken to remedy the defect must also be external to the spine. By taking such measures as the nature of the force impressed requires to counteract its effects, the spine will soon regain its normal figure in the secondary stage, without the aid of instruments of any kind applied immediately to it. The treatment of the third stage of lateral curvature is quite another thing. Now, although we know that bones will, at any period of life, change their forms under certain circumstances, yet when persons have suffered the distortion of the spine to remain many years uncounter-

acted, until they have ceased growing, it naturally remains permanent, and years of treatment, however scientific and well adapted to relieve the patient, will most probably fail. Such being the result of neglect, it is incumbent on all those who have any interest in the treatment of these affections to begin in the earliest stage, or, at latest, in the secondary stage, when success is almost certain; and not to allow the patients to fall into the third stage, when they become the subjects of experiments which usually only torture them, at the expense of their health, time, and money. While very great attention, with very unsatisfactory results, has been paid to curvatures of the spine, very little has been done with respect to curvatures of the lower extremities, and their influence on the rest of the body. As unequal curvatures of the legs, although they may be equal in length, must, if neglected, produce curvature of the spine, it surely becomes of importance to attend to those organs, since they support the whole body. In a large number of cases, surgeons have attempted to remedy distortions of the spine by machinery, when the origin was to be found in the state of the lower extremities—thus attending to the effects, rather than to their causes. When the shafts only of the long bones of the legs become distorted, they sometimes do, and at other times do not, regain their normal figures; but it often happens that in children the shafts are not only curved in more than one plane, but are also curved unequally, and then they walk very badly: if this is suffered to go on, the spine participates in the distortion, for reasons

which have been already explained. If the curvature of the leg occurs at the knee-joint, and there results an eccentric movement of the leg upon the thigh, this form of distortion does not recover spontaneously, and does not admit of being cured, unless it be taken at an early stage.

There has existed in the minds of many surgeons a repugnance to the application of irons for supporting the legs of children, on two grounds: first, on the supposition that the legs get straight spontaneously; and, secondly, that the weight of the irons is objectionable, and entails a continual expense to keep them in repair. Those who take this view forget that in standing the weight of the iron rests upon the ground, and that in walking the force of gravity swings the irons, as it does the legs themselves, with but slight muscular exertion; indeed, so far from their being an incumbrance to the wearer, they are of very great assistance. Most weak children walk much better and firmer with than without them; and the author has seen many children who refuse to part with their irons, and weep when deprived of them. With regard to their breaking, much depends on their original strength and make: the force impressed on them, and the friction at the joints in walking, require them to be well made, and their strength adapted to the age and power of the patient. Mr. Amesbury and Mr. Tamplin recommend that there should be no joint in the iron at the knee; but if the leg be kept constantly extended in walking, it tends to distort the trunk in the same manner as a wooden

leg interferes with the natural movements of the body, and it is therefore very prejudicial. The iron should be constructed so as to allow of all the natural movements of the limb, and, at the same time, to give it efficient support. This cannot be accomplished without having joints corresponding with those of the hip, knee, and ankle. It is strange, that while nearly all surgeons admit the propriety of supporting the spine, so many of them should deny the use of supporting the legs—especially since the office of the latter is to support the whole body, and of the former, only a portion of it. When the legs bend, it is really because they are not able to bear the weight of the body. Not so with the spine, which is able to support itself, but which must conform its position to the condition of the legs. Therefore to prop the spine, which is curved by the state of the legs, is just as if a person who has the foundation of his house defective, which causes the superstructure to incline, should attempt to remedy the evil by propping the upper parts, and neglecting the repair of the foundation which is the seat of the mischief. An architect would be called insane, were he to adopt such means for such an end; yet this is precisely analogous to the plan of propping the spine, and neglecting those defective states or malpositions of the lower extremities which give rise to the greatest number of cases of lateral curvatures.

CHAPTER XIV.

PHYSICAL AND PSYCHO-PHYSICAL TREATMENT OF CHILDREN.

Living animals subject to waste and renovation, growth, and decay.—Quality and quantity of food.—Supply of pure air essential to health; is not so accessible as might be supposed.—Model dwellings for the poor.—Registrar-General's report.—Laws of mortality when the density of the population varies.—Law of decrement of human life; Theory of Mr. Benjamin Gompertz.—Gymnastic and other exercises.—Organization of females; they are endowed with more strength than is generally assigned them.—No Gymnasium adequate for this metropolis.—Analytical and synthetical methods.—Surgical instrument-makers not competent to treat distortions.—No new machine proposed by the author.—Note relating to strictures written on the last paper.—Conclusion.

From the moment of birth to that of death, there exists in man, and in all animal beings, a continued struggle between the inherent organization and the extraneous decomposing forces. During the whole period, the living machine is in a constant state of waste and renovation, of growth and decay. To compensate this waste, and to maintain the life and temperature of the body in a healthy condition, a due supply of food, clothing, air, and exercise, both mental and corporeal, is requisite. The quantity and quality

of the food should be varied in each individual, according to the age and vigour of the vital functions. That a deficiency of food has a very baneful influence on health, every person is willing to admit; and on the other hand, it is no less true that an over-supply and engorgement of the system tend to the production of disease. It is not proposed to enter here into the details of what the quantity or quality of the food should be with relation to the age, sex, vital force, and exercise of the individual. The chemistry of this subject has recently occupied the attention of Liebig and others, and the quantity and quality of aliment has been made the subject of several able treatises, amongst which may be mentioned that of Dr. Barlow.*

A due supply of air and water in a tolerable state of purity is as essential to health as animal and vegetable food. Pure air, though so abundantly diffused, is not so accessible to all persons as might at first be supposed. The lower classes in the country often reside in crowded hovels, in low and damp situations, surrounded with ditches and decomposing vegetable matter; and in large towns, the same classes often congregate in cellars, and small, ill-ventilated rooms. It is in such abodes of filth and wretchedness that the victims of rickets, caries, and general distortion of the osseous system are most frequently to be found. Large and well-ventilated apartments, commensurate with the number of occupants, can be but

* Cyclopædia of Practical Medicine, vol. i.

seldom procured by the humbler classes; yet the importance of such rooms becomes manifest if we suppose, with Dr. Thompson, that 666 cubic feet of air are respired by each adult person in twenty-four hours. Indeed, when a very few persons have been together even in a large and well-proportioned, but unventilated apartment, in a short time the quality of the air is perceptibly changed; and this must be still more sensible in smaller apartments, where cleanliness is often neglected. A move is now being made in the right direction by the construction of model dwellings adapted to the poor, in which well-ventilated rooms are supplied with water, light, and heat, at an expense within the reach of industrious artisans. The Registrar-General's fifth annual report shows the ill effects in the metropolis of too many persons crowding into a given area. It is there shown that the respective mortalities of two districts are to each other as the sixth roots of the numbers expressing the densities of the population.* It would therefore seem that the agents which have a tendency to diminish the vital forces increase rapidly with the increase of population.

Intra-mural interments, the baneful effects of which have become too glaring to admit of their being much longer continued, contribute largely to the catalogue

* That is, if M, m, are the mortalities, and D, d, the densities of two districts,

$$\frac{M}{m} = \overline{\frac{D}{d}}\Big|^{\frac{1}{6}}$$

of deleterious agents affecting the health of persons living in large cities, more especially in London. The indecent and revolting churchyard scenes, so often of late brought under our notice, and the idea of which is enough to make a person shudder, and wonder that such a system should be for a moment tolerated: slaughter-houses, from which noxious effluvia escape and poison the air: and the pestilential gases which are generated in the common sewers, still open, or at least openly communicating with the streets, by grated apertures: these are a few out of the many causes operating to the destruction of human life in this vast metropolis.

Independently of the influence of extraneous causes in impairing the vital power of the system, we know by experience that the vital force in every animal diminishes in intensity as life advances. In the human race, the law of the decrement of the vital force is deducible from tables of mortality. This subject has been investigated by Mr. Benjamin Gompertz. He supposes that, taking any given number of persons of equal vital powers, the probability of death is the same; but that, taking all mankind, it is inversely proportional to their vitality. From a very elaborate mathematical investigation, he finds that, after a certain age, as persons advance in years, the advance being taken by very small increments of time in arithmetical progression, the vital power to resist destruction is continually decreasing in the same small periods of time, in a geometrical progression, the ratio of which

is as 3 to 4. An idea may be given of this law of the decrement of the vital force, by the action of the air-pump. In exhausting the air from the receiver of an air-pump, the syringe withdraws a portion of the air every time it acts, in a series of strokes which are in the arithmetical progression, 1, 2, 3, &c.; but the quantity of air left in the receiver after each stroke diminishes in a geometric progression, which will, if the piston draws out one-fourth of the contents of the receiver at each stroke, be $(\frac{3}{4})$, $(\frac{3}{4})^2$, $(\frac{3}{4})^3$, &c. In like manner, the decrease of vital force is much more rapid than the increase of years, although theoretically it is never entirely exhausted; for, as there is always a remainder of air in the receiver of the air-pump, so there is always a remainder of vital force in the body; but it becomes, in the course of time, so small, that it is insufficient to move the mechanism which carries on the vital functions, and the body yields to the destructive agents of surrounding Nature. As life is rendered apparent by the exercise of the vital functions, so death is recognised by their cessation.

Daily experience, indeed, shows that the strong and vigorous often die early, whilst the weak and delicate live for a much longer period. This manifestly arises from the difference in the circumstances under which different individuals are placed, and the amount of care which is taken of them. Some persons are more exposed to the influence of destructive agents than others; some have all the means of sustaining life in abundance, whilst others are very indifferently supplied

with these means; and hence the vital force of a weak person may be so economized, as to prolong life far beyond the terms of persons who have a greater intensity of vital energy, but with neglected or deficient means of retaining it.

The elements that enter into the composition of animals are said to be as only eighteen; but these, though few in number, combine to form more complex arrangements, and unite in higher atomic proportions, than can be found in the mineral or vegetable kingdoms. The various organic tissues of the body, which are thus formed out of complex elementary arrangements, are held together by such very weak affinities, that they begin to be decomposed, if not before, at least the instant after life is extinguished. In order to sustain the living fabric in health and vigour, all the organs of the body must be made to do their duty, and each must be exercised in a manner consistent with its importance to the welfare of the whole system; but, such is the mutual relation of each organ with the rest, that the misuse or abuse of any one disturbs the whole machinery, and the system accordingly suffers. Many inconsiderately overtax the mental at the expense of the organic functions; others tax the latter to the neglect of the former. In the earlier stages of life, when the body is in a state of active development, and the mental faculties are easily susceptible of impression, and full of vigour, the due and proportionate exercise of the mental and bodily functions is of very great importance. In the cultivation

of the intellectual powers of young people, care must be taken that the brain be not over-worked. Experience shows that every effort of the mind is attended with an expenditure of vital force. It is accordingly found that, when persons are subjected to continued mental exertion, the ganglionic or vegetative functions diminish in intensity. Even in adults, when the mind is long fixed on some subject that absorbs all its powers, the heart beats more slowly, digestion is impeded, the peristaltic movements of the intestines subside; the brain having become over-excited, the natural sleep is disturbed, and the individual starts at the least noise which interrupts his attention to the subject on which his mind is engaged. When this mental exertion is carried to its extreme limits, the vegetative functions soon become deranged so unequivocally as to point out the necessity of mental repose, and an interchange of corporeal exercise.

If such are the fruits of mental labour in the adult, at periods of life when the mind and body have attained maturity, and are therefore best able to sustain exertion, what can be expected to arise when the minds of young children are subjected to continued exercise, and have forced on them the abstract principles and construction of native and foreign languages, which they can neither retain nor understand, besides being obliged to commit to memory lengthened dissertations, and lessons tending to no immediate useful end? A cycle of acquirements is often imposed on young boys and girls, which, if accomplished, must interfere with their

physical development, if it do not entail on them a delicate constitution, probably for life. The period and amount of study should always be adjusted to the age and physical condition of the individual; and it should be remembered that great activity of mind is often associated with a scrofulous and delicate constitution. To encourage the development of the intellect in excess tends to advance the inroads of predisposed disease; the vegetative functions perform their office imperfectly, and scrofulous abscesses, rickets, caries, or some other distortion of the osseous system, often supervene. In many large schools the pupils are too much crowded together, and the rooms not sufficiently ventilated for maintaining the body in a state of health; and at certain seasons of the year the difference of temperature within and without the school-rooms is so great, that affections of the respiratory organs are very commonly the effects of exposure to these vicissitudes.

In this country the accumulation and diffusion of wealth have vastly increased during the last and present centuries; and that, too, in a far greater proportion than the increase of the population. The tendency of this general increase of wealth, in the middle classes of the community, has been to release a large mass of persons from the necessity of corporeal labour, as the means of procuring the common necessaries of life. This exemption from corporeal labour has given time and opportunity for devoting more than ordinary attention to intellectual pursuits; and thus the cultivation of

the mental powers has in a great measure superseded bodily exercises. But this tendency to cultivate the intellectual, and neglect the corporeal functions, which is due to a higher degree of civilization, refinement, and luxury, cannot be carried with impunity beyond certain limits; and those who are exempt from the necessity of bodily toil find themselves obliged to resort to it, and to induce fatigue as a means of health. In order to combine amusement with exercise, we find that those who can command the opportunity betake themselves to the pleasures of the chase; and those only who have the taste and opportunity of so doing can justly appreciate the mental relaxation produced by the sports of the field—such as hunting and shooting. But comparatively few are able to have recourse to this species of exercise; and the jealousy with which the right of sporting is preserved is a test of the value assigned to it by those who enjoy the privilege.

In the earlier period of life, when the intellectual and physical powers are in a state of progressive development, the sports of the field and equestrian exercises are in general not available, and various kinds of mechanisms have been invented and proposed as substitutes. The first object in all gymnastic exercises should be to use such means as will bring the whole of the voluntary muscles into proportionate action: they should be likewise of a nature to amuse the mind, as well as to strengthen the body; for unless these objects are combined, children will never persevere in them. For infants we have recently had introduced from

America the "infant gymnasium or baby-jumper," which is extolled in the "Letters to a Mother," by Dr. Conquest, who says that it will conduce much to the safety, health, and enjoyment of the child;" thus combining pleasure with exercise. The movement of the child in this apparatus is chiefly vertical, and therefore differs from that of the go-cart, in which the infant moves horizontally. Many games tend to the same end. What boy or girl does not delight in trundling the hoop, spinning the top, and playing at battledore and shuttlecock; games which are not only harmless, but beneficial, and which, combining amusement with exercise, have therefore become popular. The games of cricket and fives require greater exertion, and are adapted to persons more advanced in life than those just enumerated. The disadvantage of the game of cricket is the alternation of violent exertion and absolute repose with which it is attended; since the profuse perspiration consequent upon the exercise being thereby liable to be checked, exposes the players to rheumatic, catarrhal, and other indispositions. In turning our attention from those popular sports and games which tend to exercise the body, and amuse the mind, to the various machines constructed with a view to remedial purposes, we cannot fail to be struck with the total inaptitude of the latter to combine the objects just mentioned.

It has been imagined by some that the greater frequency of distortion among females is due to their bodies being more delicately formed than those of

males. This supposition would imply that Nature, so perfect in all her other works, had made the mechanical construction of woman imperfect. If, however, we look around us, a superficial inquiry will be amply sufficient to dispel such an idea. In consequence of exercise, the females of other countries are quite capable, not only of supporting the frame, but of bearing as heavy loads, and undergoing as much fatigue, as the men.* This is also observable in our own population, wherever the possession of wealth has not produced luxurious habits, excessive mental exertion, or compression of the chest, in obedience to a depraved taste. The Hindoo women are remarkable for their upright carriage, and fine figure; the Circassians also are proverbial for their exquisite beauty of proportions; they impose no unnatural restraints like corsets; and their intellectual attainments, though far below the standard of our own countrywomen, leave the physical powers greater freedom of development. Even in this country, the Welsh strawberrywoman performs labour that would wear out with fatigue most ordinary men. In many countries where civilization has not as yet elevated the intellectual standard of the female sex, the toils not only of domestic, but of agricultural and other labours are imposed on them, and there is no deficiency of mechanical power to fulfil these duties. It is, then, quite

* In the Cyclopædia of Anatomy and Physiology, Part XXIII. p. 480, the author has given the formulæ by which animal force estimated.

clear that Nature has done her part in the mechanical structure and organization of the fair sex, but that art, and irrational attempts to improve the figure bestowed on them by Providence, have worked the mischief observable in their physical constitution. Nature has imposed laws on organized beings which cannot be violated with impunity. The mutual relation between the intellectual, automatic, and mechanical functions is such, that the over-exercise of any one of these entails injurious effects on the rest. Abstract studies, and all mental exertion, ought to be followed by mechanical exercises. Walking, running, and leaping, are within the reach of all ranks; yet even these are denied to the progeny of the wealthy, and carriage exercise is substituted for them. The delicate, pale, and unhealthy chlorotic countenances of most persons thus circumstanced, sufficiently indicate the baneful effects of such a system.

Delpech has strongly insisted on the necessity of gymnastic exercises, and in his excellent work has given numerous illustrations of various kinds of attitudes and movements which tend to bring the different muscles of the body into action, to improve the figure, and to strengthen the constitution. In France, Germany, and Piedmont, gymnastic establishments are under the patronage of government. In England, they are introduced into some of the military schools; and there has lately been erected a gymnasium for the use of civilians in the neighbourhood of Primrose Hill. At

University College, London, the gymnasium is under the superintendence of Mr. Chiosso; and gymnastic exercises are enjoyed at some of the ladies' boarding schools about the metropolis: nevertheless, there is much need of some other establishments of this kind, which might be erected either by government, or by private subscription, and which should be placed under the superintendence of persons competent to direct the nature and amount of the exercises in individual cases.

When any person undertakes the study of the anatomical and mechanical functions of the organs of locomotion in man, he soon perceives that the subject opens to his view a mechanism consisting of a large number of parts connected together, and made more or less dependent on each other in a very beautiful manner. The bones, the joints, the ligaments, and the muscles, are all adapted to each other for one common end; namely, the preservation and enjoyment of the whole body. So exquisitely are the several parts adjusted, that the smallest mechanical derangement of any one entails corresponding changes in the rest. There are two methods of inquiring into the nature of these corresponding changes of attitude; namely, the inductive and the deductive. By the former method we are able to observe experimentally what changes actually take place in the body, and trace these effects to their causes; and by the latter, we may state each particular case either as a problem for solution, or a

theorem for demonstration; but whichever method is adopted, or if they are combined to suit particular cases, the student will find in human mechanics enough to engage a large portion of his life. We have had physico-mathematical problems solved by Mayow, Borelli, D. Bernouilli, Barthez, W. and E. Weber, and others. He who desires to attain a knowledge of the human body, viewed as a moving machine, will be amply repaid his labours by studying MM. Weber's "Mechanik der menschlichen Gehwerkzeuge," which gives an excellent idea of the nature of these subjects. In some cases the analytical method requires to be verified by experiment; such, for example, as the swinging of the leg in walking, inasmuch as there are powerful muscles adapted to draw the leg forwards, and the presumption was that they did do so, until the Webers demonstrated analytically that it was impelled forwards like a pendulum, by the force of gravity alone; and perhaps the demonstration would not have been sufficient to establish the truth in the minds of mere anatomists, if they had not shown that the leg of a dead man, placed under proper circumstances, swung rather faster than that of a living one. Few who are ignorant of dynamics can be made to believe that, in walking, the forces which propel the body forwards are not greater than those which drive it back; yet such must be the case in all bodies moving uniformly. Inquiries like these awaken attention to a higher and more philosophical method of inquiry into the theory of

animal mechanics, more especially with reference to the human race; and such a knowledge of this subject is of paramount importance in the study of those cases where changes of attitudes lead to distortion of figure.

The author has simply, in this work, attempted to trace to their sources the failure of the various methods in use,—to expose the empirical state of the practice both abroad and at home,—and to lay down some rules founded on established premises as guides for future treatment. When we take a survey of the vile machines that have been invented, and consider the amount of torment inflicted by them for no useful end,—that patients have been subjected, often for years, to painful restraint, have incurred expense, and lost much precious time, all which has been borne with fortitude by the young and delicate, buoyed up by the fallacious hope of a happy result; and that muscles and tendons have been cut, and various other mutilations inflicted on a mechanism so beautiful and so perfect as that of the human body, in order to attain objects which such means could never accomplish,—it must be acknowledged that this branch of surgery is in a most deplorable state. Almost every orthopedic practitioner has hitherto employed some favourite machine for the treatment of distortion. The author does not intend to propose any new machinery, either for stretching, pulling, pushing, or propping the body; his aim being to dispel the illusion that such machines possess any value, by demonstrating their inefficiency

in the majority of cases, and thus to pave the way for a more scientific and rational practice in this branch of surgery.

It is to be hoped that henceforth surgeons will not be content to transfer their distorted patients to the care of surgical instrument-makers. In all the ordinary affairs of life, a person who finds that his steam-engine, his carriage, or his watch, has got out of order, applies to the engineer, the coachmaker, or the watchmaker, to get it repaired. Who would employ a blacksmith to repair his chronometer? And yet surgeons send the human frame, vastly more delicate, more elaborate, and more complex than any piece of artificial machinery, to be repaired by an instrument-maker, whose knowledge of its physico-mathematical constitution is incomparably less than that which the blacksmith has of the chronometer. A case affording a striking illustration of the bad effects of this mistake has been recently placed under the author's care, where stays furnished with crutches had been worn by a young lady three years; during which time, the patient grew every day worse and worse, until the failure of the plan became too apparent for its longer continuance. The body is now dreadfully distorted, and the opportunity has been lost for effecting a cure; which might have easily been accomplished, had proper treatment been applied in the earlier stage, instead of trying the experiments of an unprofessional empiric. It would be easy to prolong the discussion of the subject of this work almost indefinitely, by entering into matters of detail; but the

object throughout has been to establish some general scientific principles in orthopedic surgery, on which the practice might be founded; for the specific treatment of each case must depend on its own peculiarities, which are only to be detected by the skill of the surgeon.

THE END.

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ADVERTISEMENT.

A PORTION of this Work, on the completion of which the Author had been laboriously engaged within a few days only of his decease, had been already consigned to the press, when his Widow and Executrix placed in my hands the copious Manuscript and Explanatory Notes of my late highly valued friend and former teacher, in order that I might superintend its passage through the Press.

For the grateful task of editing this, the Author's last Work, I possessed both the requisite leisure, and a long-standing acquaintance with his scientific views and methods of investigation; and most amply shall I be rewarded should I be deemed to have discharged this duty, without detracting from the well established reputation of the Work.

I may perhaps be allowed to state that the Author, at the request of a Committee of the Royal College of Physicians appointed to revise their Pharmacopœia, either conducted or inspected the preparation of most of the medicines which have been introduced, or the methods of preparing which have been altered in the present Pharmacopœia.

In the Remarks which accompany this Translation, the Author's attention and my own have been especially directed to those engaged in the practice of Physic, but who from the demands of their professional avocations have not watched the important and rapid progress of chemical science; to Medical

Students, to whom concise yet distinct descriptions of the chemical changes which occur during the preparation of medicines are extremely useful; and lastly, to those engaged in the preparation and dispensing of drugs, to whom methods of ascertaining the purity and freedom from adulteration of the materials they employ will prove advantageous. To the directions and tests of the Pharmacopœia such remarks have been added as seemed to further the purpose of their introduction, and the tests which have been proposed are the more necessary because the College no longer insist that the medicines which they have ordered should be prepared exactly in the mode prescribed, provided they will stand the trial of their purity to which they should be submitted.

They who know how small that portion of time is which the student of medicine has at his disposal for the acquirement of chemical and pharmaceutical knowledge, will readily admit the utility of assisting his progress by familiar modes of illustration. With this view much use has been made of diagrams in this work, and for an example of the method of framing them I refer to those which occur in pp. 309–10, illustrating the preparation of Chloride of Mercury. The materials employed and waste products, as Sulphuric Acid and Sulphate of Soda, are printed in the usual type; the constituents of the materials in italics, as *Oxygen* and *Sodium*; the intermediate products, when such occur, in very small type, as Sulphate of Mercury; and the Pharmacopœia preparation in small capitals, as CHLORIDE OF MERCURY.

I have deemed it my duty, so far as I was able, strictly to carry out the Author's design of making the present Work a Compendium of whatever is yet known respecting the more important chemical pro-

perties of every substance and preparation inserted in the Pharmacopœia, and therefore whenever an article of the Materia Medica is used in a preparation its chemical and physical history is given, either under the first, or the most important preparation in which it occurs; thus, the descriptions of the Cinchona barks and of the alkaloids derived from them are appended to Decoctions of Cinchona, those of Tartaric acid and of its potâsh salts occur under Potassio-tartrate of Antimony, and Tannic and Gallic Acids under Tincture of Galls; an arrangement which is not only a rational one, but is also convenient and instructive to the Student. Whatever defects this arrangement may be chargeable with, I trust will be at least compensated by the copious index annexed to this book. Several processes which occurred in the last Pharmacopœia, the products of which are now inserted in Materia Medica, are retained in this Work, as not only being useful to those practitioners who may be desirous of preparing their own chemicals, but also frequently affording excellent practice for the student in operative chemistry and pharmacy in the use and management of chemicals and of apparatus: these re-inserted formulæ are invariably printed in italics; but the former Pharmacopœia processes have not always been restored, for if obviously better methods, as in Liquor Ammoniæ, p. 103, have come under my notice, these have been preferred and are printed in similar type to that of the rest of the notes and remarks.

Symbols and formulæ of the definite chemical products and compounds have been given, and these formulæ have been adopted in the Table of Equivalents appended to this Work, as they not only denote the ultimate composition of the substances contained in the Table, but they will also

enable students to familiarize themselves with the use and employment of chemical symbols and formulæ.

I have freely availed myself in this work of the views and results of chemists, and of the labours of various writers on Materia Medica and Pharmacy, and have adopted whatever information I have met with of a reliable and suitable kind frequently without specific acknowledgment of its source, as will be evident to all who are versed in these departments of science.

Well knowing how necessary it is that the student should be acquainted with the powers and doses of medicines, I have generally given an account of them; but not being a medical practitioner, I have consulted and quoted the best authorities on the subject; and it may inspire confidence in this statement to observe, that these have been for the most part transferred from the translation of the last Pharmacopœia, for which the Author was then chiefly indebted to the friendly assistance of the President of the College of Physicians, and to Dr. Hue of St. Bartholomew's Hospital. My most emphatic thanks are due to Mr. Warington of Apothecaries' Hall, for the valuable information and efficient aid he has constantly afforded me whilst this Work was passing through the Press.

J. DENHAM SMITH.

Putney, September 1851.

NAME	DATE DUE